Aeroplane Maintenance and Operation Series, Volume 13

ENGINES

(PART 3)

AEROPLANE MAINTENANCE AND OPERATION SERIES

Compiled under the General Editorship of E. MOLLOY

VOL. NO.

1 CARBURETTORS (Part 1)
[illegible] more popular [illegible] chapter dealing with [illegible] Control. With 85 [illegible].

2 INSTRUMENTS (Part 1)
Very detailed treatment is devoted to the Sperry Gyropilot, the Sperry Artificial Horizon and the Sperry Directional Gyro, also to Smith's Aircraft Instruments. With 140 photographs and diagrams.

3 LANDING LEGS, WHEELS AND BRAKES
The maintenance and repair of the Lockheed Airdraulic Oleo Leg, the Vickers Oleo-pneumatic Shock Absorber Strut, the Turner Oleo [illegible] and Pneumatic Landing Legs, the Dowty Oleo-[illegible] and Tail-wheel Units. Dunlop [illegible] Brakes, etc. With [illegible] photographs and diagrams.

4 AIRSCREWS (Part 1)
Maintenance and repair of the de Havilland Controllable-pitch [illegible] and Hydromatic Airscrews. Dismantling, [illegible].

5 ENGINES (Part 1)
The maintenance and repair of the Armstrong Siddeley Cheetah IX, the Tiger VIII and Lynx IVc Engines. With 71 illustrations.

6 AIRFRAMES (Part 1)
Inspection and repair of some representative types of British and American Airframes, with notes on the use of welding for airframe repairs. 106 illustrations.

7 MAGNETOS
The maintenance, repair and operation of Scintilla, Rotax and the British Thomson-Houston types of Magnetos. With Trouble Tracing Charts. 82 illustrations.

8 THE LINK TRAINER
Covers comprehensively the installation, maintenance and adjustment of the Link Trainer used for the training of pilots in Instrument Flying. Also deals with Trainer instruments. 61 illustrations.

9 ENGINES (Part 2)
Gives detailed instructions for the dismantling, operation, repair and maintenance of the de Havilland Gipsy Twelve, Gipsy Major Series II, Gipsy Two and Gipsy Three Engines. 57 illustrations.

10 HYDRAULIC EQUIPMENT
The operation, inspection and maintenance of Lockheed, Dowty and other representative types of hydraulic equipment, with a summary of retractable undercarriages and operating systems. 84 illustrations.

11 AIRFRAMES (Part 2)
The inspection and repair of some representative types of British Airframes—principally the Luton range and the Westland Lysander I. 118 illustrations.

12 STARTERS AND GENERATORS
The operation and maintenance of Rotax Starters and Generators, B.T.H. and Siddeley Starters, and Gas Starters. 67 illustrations.

13 ENGINES (Part 3)
Dealing with the maintenance and repair of the Wright Cyclone, Bristol, Pobjoy, and Continental Engines. 75 illustrations.

14 AIRFRAMES (Part 3)
Representative types of British and American Airframes. With notes on the repair of metal hulls and floats. 109 illustrations.

15 INSTRUMENTS (Part 2)
Dealing with K.B.B. and K.B.B.-Kollsman Instruments, and the operation and maintenance of the Smith Automatic Pilot. 110 illustrations.

16 FUEL AND OIL SYSTEMS
Deals with the maintenance and repair of the fuel and oil systems on representative types of aeroplane. With notes on testing aeroplane fuel. 103 illustrations.

17 AEROPLANE RADIO EQUIPMENT
Dealing with Marconi, Standard and North American Radio Equipment. With special notes on Direction Finding Equipment, Lorenz Equipment and Bonding and Screening. 59 illustrations.

18 CARBURETTORS (Part 2)
Zenith, Rolls-Royce and Stromberg Carburettors, with special notes on Boost Pressure Control and Cambridge Exhaust Analyser. 106 illustrations.

19 AEROPLANE AUXILIARY EQUIPMENT
Extinguishing Equipment, Batteries and Sparking Plugs, Ignition Screening Harness, De-icing Equipment and Parachutes. 104 illustrations.

20 AIRSCREWS (Part 2)
Dealing with Rotol, Curtiss, Hamilton and Hele-Shaw Beacham Airscrews. 62 illustrations.

21 AERO ENGINE PRACTICE
A survey of aero engine types, and present-day practice in installation, operation and servicing. With summary of Ground Engineers' Licence regulations. 103 illustrations.

22 AIR NAVIGATION (Part 1)
Deals with air pilotage, and dead-reckoning, maps and charts, instrument flying, astronomical and radio navigation, and meteorology. 67 illustrations.

23 AIR NAVIGATION (Part 2)
Covers magnetic compasses and methods of adjustment, navigational calculators, drift sights, sextants, directional radio systems and the use of radio beams. 65 illustrations.

24 ENGINES (Part 4)
Deals fully with the Dagger VIII and Cheetah X Engines. 54 illustrations.

25 ENGINES (Part 5)
Maintenance and repair of the Pratt and Whitney "Wasp" and "Hornet" Engines. 21 illustrations.

26 ENGINES (Part 6)
Full information on the latest models of the Wright "Cyclone" Engine. Illustrated.

27 AERO ENGINE CARBURETTORS
By E. W. Knott.
A comprehensive work on general principles of carburation, timing, testing, maintenance and repair. Illustrated.

Price 7s. 6d. net per volume

Aeroplane Maintenance and Operation Series, Volume 13

ENGINES

(PART 3)

DEALING WITH THE MAINTENANCE AND REPAIR OF THE WRIGHT "CYCLONE," BRISTOL, POBJOY, AND CONTINENTAL ENGINES

General Editor

E. MOLLOY

Advisory Editor

E. W. KNOTT, M.I.A.E., M.S.A.E.

COMPILED BY A PANEL OF EXPERTS

WITH SEVENTY-FIVE ILLUSTRATIONS

GEORGE NEWNES LIMITED

Tower House, Southampton Street, Strand

LONDON, W.C.2

First Published . . 1940
Reprinted 1941

PRINTED IN GREAT BRITAIN BY HAZELL, WATSON & VINEY, LTD., LONDON AND AYLESBURY

PREFACE

EARLIER volumes in this series have dealt with the Armstrong Siddeley range and the Gipsy range of engines respectively. The present volume deals with two further famous British makes, namely, the Bristol and Pobjoy, and also two American types which are being used in increasing numbers on this side of the Atlantic—the Wright "Cyclone" and the Continental range.

The Wright "Cyclone" engine provides an excellent example of the American practice in radial aero engines.

As the present work has been designed to provide practical instruction on the approved methods of servicing and overhauling engines, it has not been considered necessary to enter into a detailed description of the construction. The ground engineer who is called upon to dismantle and overhaul the Wright "Cyclone" engine will of necessity have an actual specimen of the engine available for detailed examination, and the author of this first section has had in mind that the information which is required by an operating engineer is detailed instructions as to the exact procedure to be followed in stripping, examining, adjusting, and reassembling the engine and its various components. This information has been provided.

By special arrangement with British Airways Limited, it has been possible to obtain a series of action photographs to illustrate many of the operations involved in the above work, and, in this connection, it may be pointed out that these photographs were taken during the actual overhaul of a Wright "Cyclone" engine under service conditions. Thus the operations illustrated and described represent, in a clear and practical manner, the approved methods of carrying out this work. After the dismantling and overhaul have been dealt with, full and clear instructions are given for installing the engine together with its accessories and airscrew in the aeroplane.

The procedure followed in the case of Bristol engines is on rather different lines. In this case, where two distinct types are covered, namely, the poppet-valve and sleeve-valve, the overhaul, testing, and adjustments have been dealt with separately for each type. The maintenance notes, which are included at the end of this section, cover both the poppet-valve and sleeve-valve ranges. Wherever there is any variation between the two types in the routine to be observed, attention has been drawn to this.

In the Pobjoy range, three particular engines have been covered, namely, the "Niagara III," the "Niagara IV," and "Cataract IV." In this case also, an interesting series of action photographs has been

included to illustrate some of the more important operations referred to in the text. The section concludes with practical notes on inspection.

The Continental "W670" engine forms the subject of the concluding section. This is another good example of American practice in radial engine construction. As this engine is not yet in such wide use in this country as is the Wright "Cyclone" engine, some space has been devoted to a description of the engine before entering upon the more severely practical aspect. Then follow notes on operation and maintenance, and, finally, instructions are given for carrying out a major overhaul, including inspection and reassembling.

In the case of the Continental A-50, A-65, and A-75 engines, a similar plan has been followed.

It is obvious that the information here presented could only have been compiled through the co-operation of the makers of the respective engines which have been dealt with.

We take this opportunity of expressing our thanks to the firms concerned :

Wright Aeronautical Corporation.
Bristol Aeroplane Company, Ltd.
Pobjoy Airmotors and Aircraft, Ltd.
Continental Motors Corporation.

We should also like to thank British Airways Limited for the special facilities which they afforded us to obtain the action photographs which have been used to illustrate the sections on the Wright " Cyclone " and Pobjoy engines.

E. W. K.
E. M.

CONTENTS

ENGINES

THE WRIGHT "CYCLONE" ENGINE

THE purpose of this article is to describe, in general, the overhaul of a Wright "Cyclone" engine. No fits or clearances will be given as these are altered from time to time by the makers in the light of their experience. If the overhaul of this type of engine is contemplated, reference should be made to the "Service Manual" and "Overhaul Manual" published by the Wright Aeronautical Corporation, to whom the author is indebted for much of his information.

On arrival of the aeroplane for an engine change, the oil should first be drained off, preferably while the engine is still warm. The airscrew should next be removed. After the fuel has been turned off in the cockpit, all pipe lines can be disconnected at the fire wall. Break all electrical circuits by withdrawing the Cannon plugs on the fire wall.

The engine is now ready for removal, and the engine sling, together with its spreader bar, should be attached to Nos. 2 and 9 rocker boxes. Then, with the engine supported by a suitable lifting tackle, the four main bearer bolts at the fire wall can be removed and the engine swung clear.

This engine installation should be mounted on a stand specially prepared for the purpose. The installation is now ready for the removal of all the pipe lines, electrical harness, nose ring of the engine cowling, and the accessories, such as generator, starter, constant-speed governor, vacuum pump, etc. The pipe lines should be removed in order, and, after cleaning, should be inspected for condition, repaired if necessary, and the ends bound up and stored, awaiting building up into a new installation. The electrical harness and accessories should be cleaned, overhauled, and tested in accordance with their various requirements. When all the accessories, etc., have been removed, the engine should again be supported on the lifting tackle, and the nine main bearer bolts removed from the engine mounting ring, allowing the engine to swing out of the bearer frame for transfer to an engine stand.

Dismantling the Engine

The first step in the dismantling of the engine is to remove the magnetos, after the removal of the magneto shields. This is effected by removing the three nuts holding the magnetos on to the rear cover,

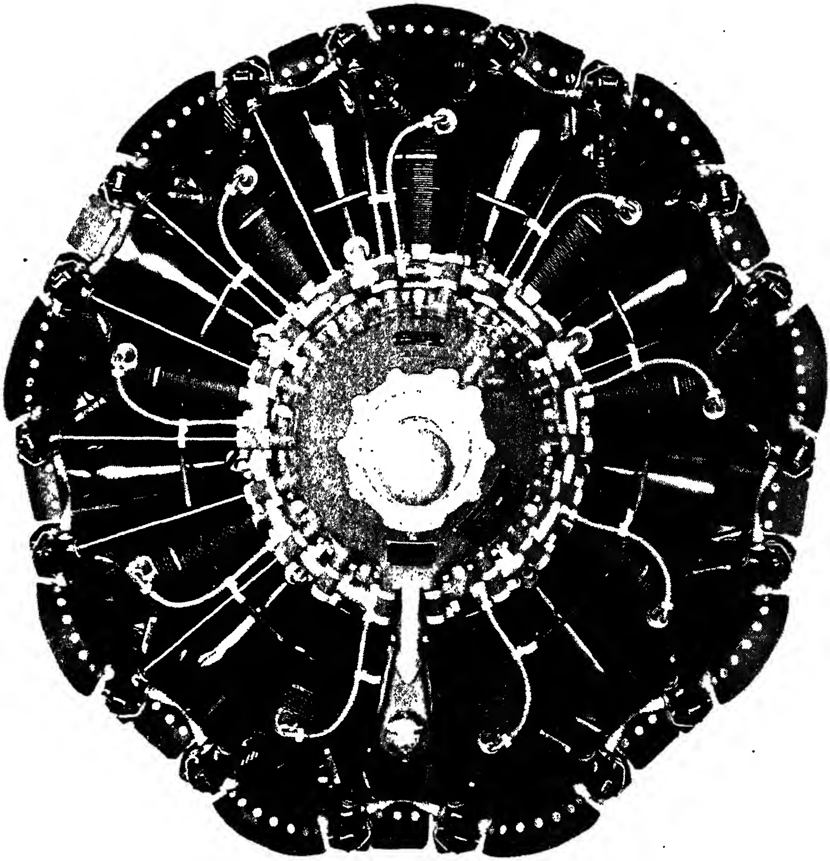

Fig. 1.—Front view of a typical Wright "cyclone" engine, the "F.50" model

and withdrawing the magnetos rearwards. The ignition leads should be removed from the distributor blocks, and these blocks, together with their respective magnetos, should be passed to the electrical department for overhaul. The rear cover and blower section rear can now be removed complete. After removal of the palnuts and nuts holding this assembly on to the blower section front, the assembly should be withdrawn carefully, after breaking the joint, in order not to damage the splined end of the crankshaft extension.

The Power Section

Now the engine should be turned up so that the airscrew shaft is vertical, and the dismantling of the power section carried out in the following order.

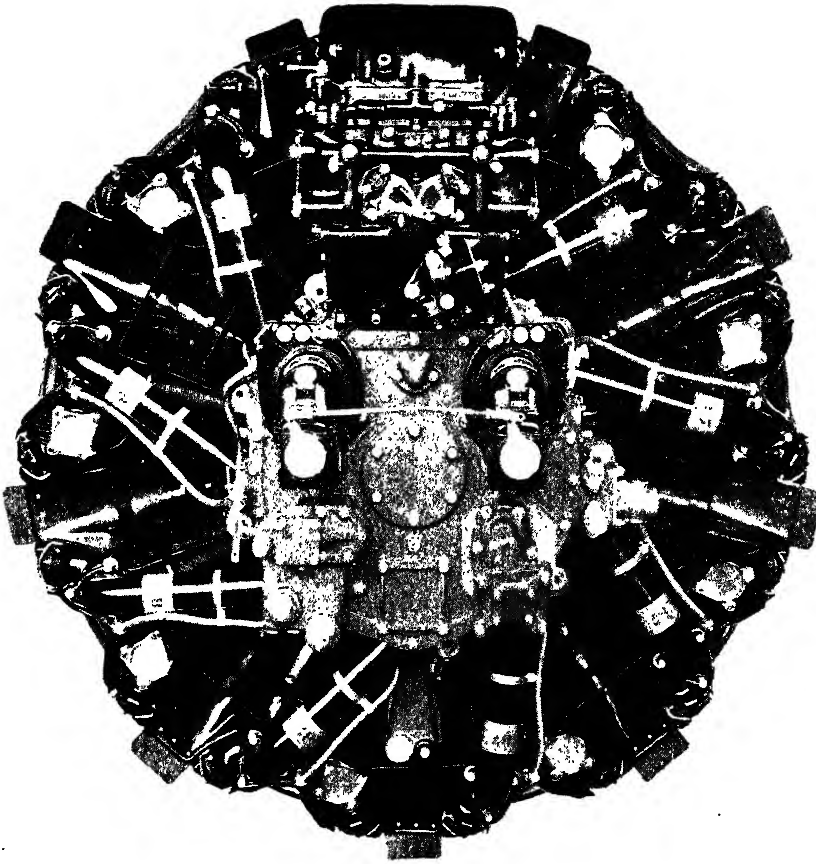

Fig. 2.—Rear view of the Wright "cyclone," model "F.50"

First remove the cylinder head and the inter-cylinder baffles. The head baffles are attached to the heads with two capscrews, while the inter-cylinder baffles are kept in position by a clamp and spring—this does not apply to the baffle between Nos. 5 and 6 cylinders, which is held in place by a capscrew screwed into a brass insert in the base of the sump.

Next the rocker gear and push rods should be removed, having first taken off the rocker-box covers. This is a simple operation, necessitating only the removal of the nut and bolt through each rocker arm, allowing the arms to come out of the rocker boxes, followed by the push rods. The rocker adjusting screws can be removed by slackening off the clamp screws, and screwing them out of the rocker arms. These parts are now ready for cleaning.

The push-rod housings should next be removed by slackening off the hose clamps and pulling out the housings. The rubber hoses at each end of these housings can be discarded, as these are replaced at each overhaul.

Induction Pipes and Ignition Harness

Withdrawal of the induction pipes can now be carried out by slackening off the gland nuts in the blower section, removing the three capscrews which pass through the induction-pipe collars into the cylinder heads, and pulling out the induction pipes. The ignition harness may now be removed by freeing the attachment lugs which are held down by the nose-section retaining nuts, and the ignition lead clamps under the cylinder-base nuts.

The Nose Section

Before removal of the nose section can be effected, it is essential to withdraw the tappet assemblies from the nose section. The tappet sockets and springs can be freely withdrawn, and the tappet guides drifted out after removal of the two retaining nuts on each. The tappets can then be removed from their guides by tapping them smartly downwards with a soft drift, thus springing the retaining circlets out of their grooves in the top of the tappets. When the tappets are free of their guides, the tappet rollers and pins are liberated and can be withdrawn. The nose section complete can now be removed by means of a lifting eye screwed on to the front thread on the airscrew shaft.

When this nose section has been lifted clear, it should be placed on the bench with a block of wood or some similar material inside to support the airscrew shaft when the thrust nut is undone. This thrust nut should be undone with the spanner supplied, holding the airscrew shaft with the special turning bar provided. When the nut has been completely undone, it can be removed, and the nose section can then be lifted off the airscrew shaft.

The withdrawal of the eight nuts will permit the removal of the front aluminium cover and the de-icer plate (if fitted) from the nose section. The little circlets should then be removed from the bolts, allowing the steel front-cover plate to come away. These bolts should next be removed, and then, after removing the two nuts inside the nose section, the fixed gear of the reduction gear train and the ball thrust race may be withdrawn from inside the nose section. It is now only necessary to remove the small casting carrying the constant-speed governor reduction gears, to complete the dismantling of the nose section.

Planet Gears

The six planet gears should next be removed from the rear of the airscrew shaft. This is effected by removing the split pins from the brass nuts, and screwing these nuts out of the pinions (see Fig. 20).

It should be borne in mind that these nuts are screwed in with a left-hand thread. The thrust bearing spacer should be withdrawn from the front of the airscrew shaft complete with its oil transfer rings. These rings may be removed from the spacer, as they are replaced at every overhaul. This completes the dismantling of the nose section and airscrew shaft.

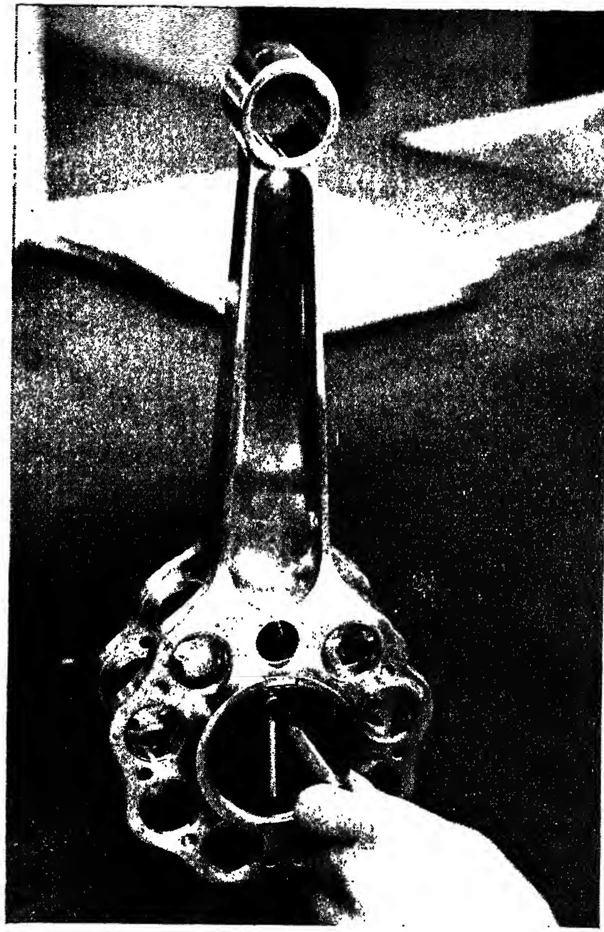

Fig. 3.—Checking diameter of big end bearing

We are indebted to Messrs. British Airways Ltd. for facilities for staging the accompanying series of action photographs.

Removal of Cylinders, Pistons, and Gudgeon Pins

The next step in the dismantling of the engine is the removal of the cylinders, pistons, and gudgeon pins. This is accomplished by removing the twelve palnuts and cylinder-base nuts and withdrawing each cylinder in turn. The cylinder in which the master rod is located, i.e. No. 4, should be removed last, otherwise the bottom rings in the remaining cylinders will foul the cylinder spigots if the crankshaft is turned. After the removal of each cylinder, the bottom or rear circlip in the piston should be removed and the gudgeon pin tapped out, using a soft drift that seats within the gudgeon pin, so as not to damage the gudgeon-pin bush in the link rod.

A block of wood should then be placed in each cylinder in turn, to facilitate the removal of the valve and valve springs. After the block

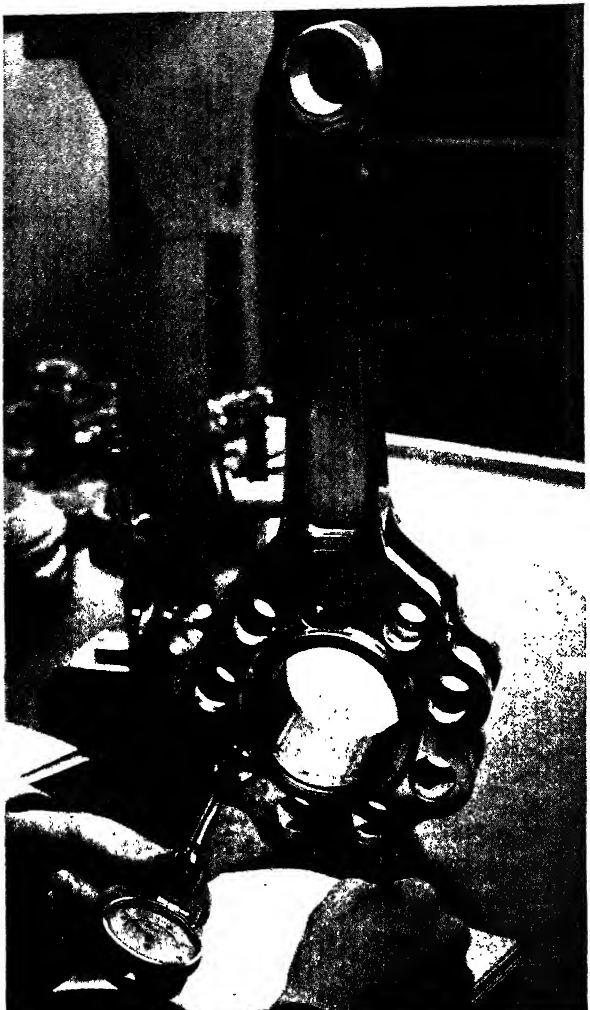

Fig. 4.—Checking knuckle-pin bores in master rod with "Subito" gauge

of wood has been inserted in the cylinder, the special tool (see Fig. 16) should be attached to the rocker box with the pin provided. The valve springs can then be depressed and the collets removed. The cylinder should be removed from the block carefully, so that the valves do not drop in and damage the cylinder walls. The circlips and all the piston rings should next be removed from the pistons, as these—the circlips, etc.—are replaced at every overhaul.

Reduction Driving Gear

The reduction driving gear should next be removed from the engine. This is effected by, first, removing the split pin from the retaining-nut locking screw and then undoing the locking screw. In order to slacken off the nut, it will be necessary to hold the crankshaft, and this is best done by placing an old gudgeon pin in the master rod (No. 4 cylinder position) and supporting it top and bottom with blocks of hard wood. These latter should be specially made for this purpose, and should be drilled to fit over the cylinder-base studs.

After the nut has been undone with the special spanner provided, and removed, the extractor for the reduction driving gear should be

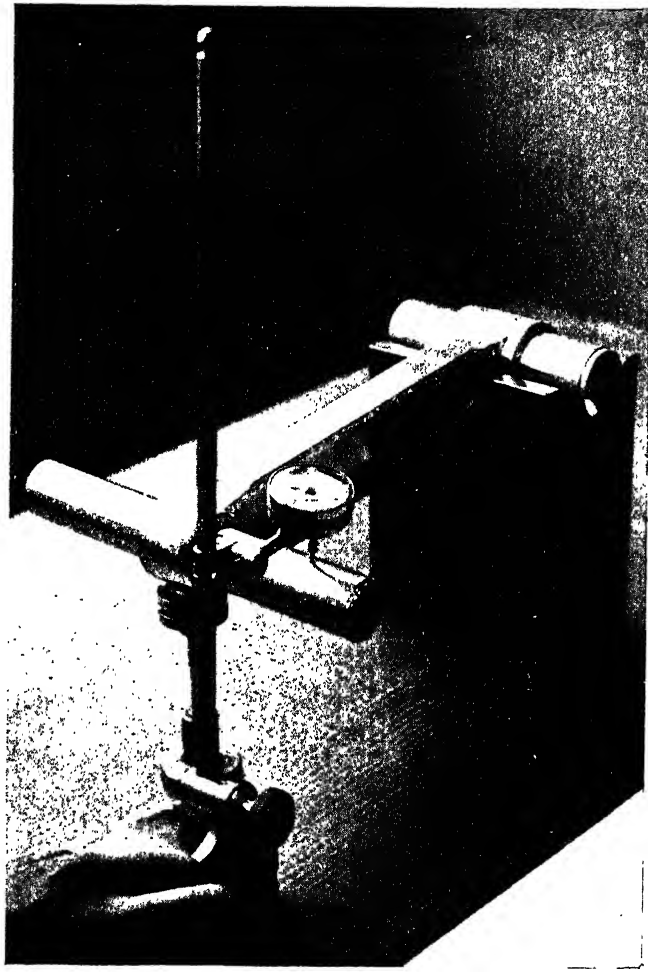

Fig. 5.—Checking articulated rod for twist

placed over the crankshaft, and the three bolts screwed into their appropriate holes in the gear. The gear can then be removed by screwing down the extractor bolt. It will then be found that the cam can be lifted off, followed by the cam thrust plate.

The cam reduction gear may now be removed by inserting an Allen wrench in the nut, pressing down the centre lock, and undoing the nut.

After the removal of the three nuts holding the cam reduction gear bracket, the oiling tube should be forced back against its spring, free of the bracket (see Fig. 13), which can then be removed. The cam driving gear on the crankshaft can now be pulled off, followed by the oiling bracket, after the removal of its four retaining nuts.

All split pins and nuts should now be removed from the main crankcase bolts, and the bolts withdrawn. The extractor should again be placed over the crankshaft and the flange secured to the oiling bracket studs. The front half of the crankcase, complete with the front main bearing, may now be withdrawn.

Crankshaft and Master Rod Assembly

Having screwed the special lifting loop on to the crankshaft, this assembly can then be raised out with the aid of suitable lifting tackle, and placed in the crankshaft assembly jig. The dismantling of the crankshaft and master rod assembly can now proceed.

The first step is to remove the split pins from the crankshaft bolt and rear roller race retaining nut. This latter nut should be slacked off first, with the spanner provided.

The main crankshaft bolt should now be undone and removed, so that the wedge provided can be inserted. The insertion of this wedge releases the grip of the rear half of the crankshaft on the crankpin, so that it can be withdrawn freely. The two bolts holding the counterweight retainer plate should now be taken out. This will allow the counterweight to be lifted, permitting the withdrawal of the support spools, thus allowing the counterweight to be removed from the crankshaft.

The rear roller race should then be carefully pressed off the rear half of the shaft, and the oil retainer plate removed from the front face of this section, by undoing the four fillister-head screws.

The master-rod assembly may now be withdrawn from the crankpin, and after tapping down the tabwashers, the bolts retaining the oil plug in the crankpin and the rear breather tube support in the crankshaft, may be unscrewed, allowing these parts to be withdrawn.

After the removal of the eight fillister-head screws from the four knuckle-pin lock plates on the master rod, these lock plates should be removed, and the master-rod assembly is then ready for the removal of the knuckle pins. Short support pieces should be inserted between the webs of the master rod, and then, with this assembly suitably supported, the knuckle pins should be pressed out singly in some form of hand press, thus allowing the articulated rods to be removed.

Rear Half of Crankcase

The next operation is to remove the rear half of the crankcase from the front half of the blower section. First the diffuser plate in the blower section should be removed by undoing the ten countersunk screws which hold it in to the blower section. The twenty-seven nuts and spherical washers in the crankcase should now be undone, and these two sections can then be separated.

Blower Section

It now remains to dismantle the blower section—rear half—and rear cover which was first removed from the engine as a unit. The cover of the accessory gearbox should first be removed, and after lifting out the gears, the box itself may be withdrawn. The oil pump should next be removed from the rear cover, after undoing the nine retaining nuts.

The drive spline can then be extracted from the front of the oil pump with the extractor provided. The front cover and rear adapter plates should then be eased off the oil-pump body, after which the oil-pump gears are free to be taken out.

Fig. 6.—Checking valve spring strength

It is important to remove the driving scavenge-pump gear first, and to extract the woodruff key from the shaft, before attempting to withdraw the shaft forwards, otherwise some damage will be done to the case. The generator and magneto shaft oil seals should next be extracted with the puller provided, after the removal of the single retaining screw from each.

All nuts and bolts holding the rear cover on to the blower section (rear half) should now be undone, and the gun synchroniser blanking plates—if fitted—removed; the rear cover can then be withdrawn from the blower section (rear half) by screwing three extractor bolts into the holes provided for the purpose in the rear cover flange.

The magneto, accessory, and generator drive gears may then be lifted out of the rear cover, and the crankshaft extension withdrawn from the impeller shaft. The spring drive outer gear can be removed from the crankshaft extension by undoing the five fillister-head screws, lifting off the cover plate, and pushing out the springs complete with end pads.

The brass lock provided in the tool kit should next be inserted between the blower section and the intermediate blower gear, and after bending down the tab out of the front impeller-shaft nut, and removing the locking rivet from the rear nut, these nuts can be slackened off with the special

spanners provided. The front nut should be removed first, and after withdrawing the front seal ring carrier, the impeller can be extracted with the puller provided.

The countersunk screws holding the impeller-shaft thrust retainer into the blower section should next be removed, allowing the impeller shaft, complete with thrust retainer, distance shim, and rear seal-ring carrier, to be withdrawn from the blower section. The rear impeller-shaft nut may then be undone, allowing the thrust retainer, together with the spherical thrust washer and its seating to come off the impeller shaft.

This completes the dismantling of the engine, which should now be passed to the cleaning department for thorough cleaning, prior to inspection.

CLEANING THE ENGINE

All sections of the engine should be thoroughly washed and cleaned. All traces of carbon deposit should be removed from such places as the cylinder heads and pistons by some approved method.

There are various brands of chemical cleaner and carbon remover on the market, but reference should be made to the Wright Aeronautical Corporation before using any of these on the engine, as their application may be injurious to the particular materials used in its construction.

INSPECTION OF THE ENGINE PRIOR TO REASSEMBLY

The inspection of the engine should be carried out in a systematic manner and with the guidance of some form of inspection sheet, similar to those illustrated in the " Overhaul Manual " of the Wright Aeronautical Corporation.

Before commencing the inspection of the engine, reference should be made to the Service Bulletins published from time to time by the Wright Aeronautical Corporation, to ascertain whether any modifications which should be incorporated during the overhaul have been suggested by the manufacturers. It is proposed here to deal generally with the inspection of the engine, making individual mention only of those parts, or operations, which are of especial interest.

Aluminium-alloy Sections

All the aluminium-alloy sections of the engine, i.e. the nose section, crankcase, blower sections, rear cover, etc., should be carefully inspected visually for signs of cracking, or for wear or damage that may have been sustained either in the normal course of events or during the removal and dismantling of the engine.

Bushings

All bushings in the engine, such as the master-rod bushing (see Fig. 3), gudgeon pin, and knuckle-pin bushings in the articulated rods,

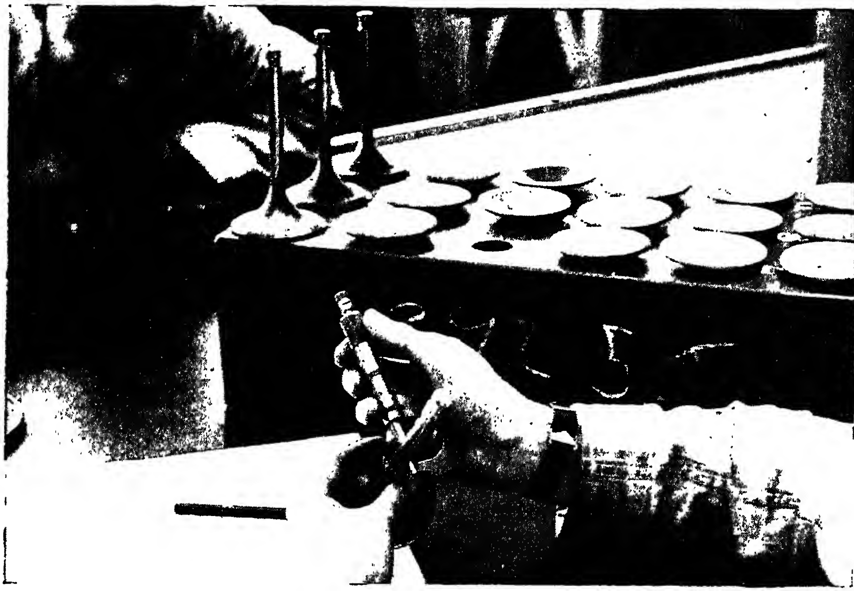

Fig. 7.—Checking size of inlet valve stem

and the accessory drive-shaft bushings in the rear cover, should be carefully examined for signs of scoring and pickup, and their dimensions checked to discover their running clearances on their particular shafts.

Knuckle-pin Holes

The knuckle-pin holes in the flanges of the master rod should be examined for signs of scoring, caused by the knuckle pins being pressed in or out. If these holes are in good condition, they should be measured for diameter and ovality with a sensitive measuring instrument, such as the "Subito" gauge illustrated in Fig. 4. These hole sizes should then be checked against the sizes of the knuckle pins to be fitted to each individual hole, to ensure that sufficient interference fit is obtained. The articulated rods should be checked on a surface plate for bow and twist, in the manner shown in Fig. 5.

Cylinders

The cylinders should be checked for wear with a "Subito" gauge, or some similar type of measuring instrument. If their ovality of taper exceeds the maximum permitted by the manufacturers, they should be rebored in accordance with one of the manufacturers' repair schemes.

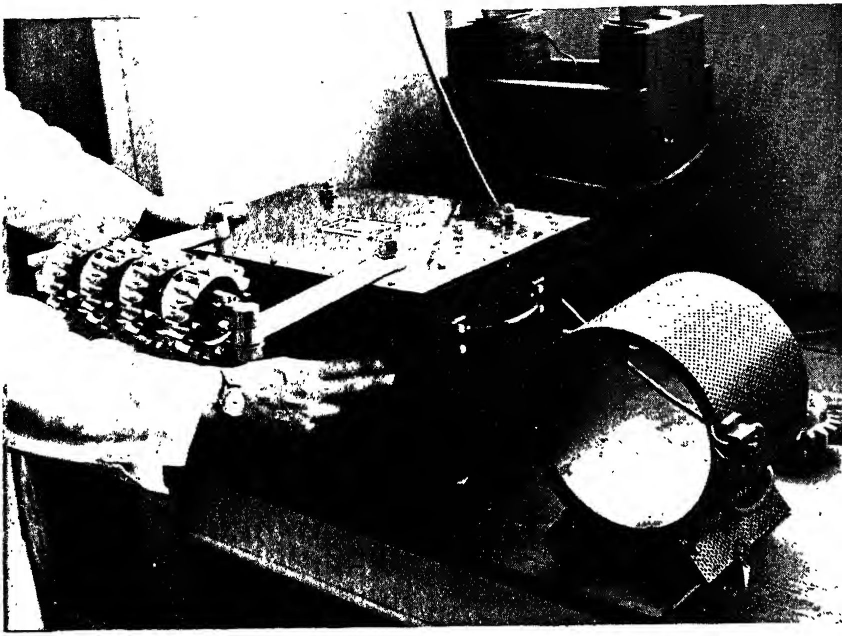

Fig. 8.—Crack detecting with Johnson-Fel detector on reduction gear pinions

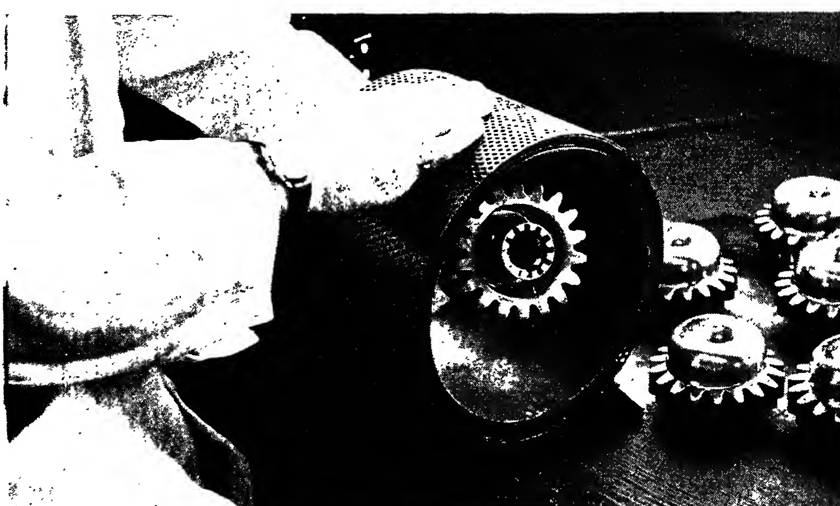

Fig. 9.—Demagnetising pinions after test

Valves

The valve guides should be checked for wear, and the head examined visually for signs of cracking or damage. The strength of the springs should be tested at a predetermined length, as shown in Fig. 6. The valves should be subjected to a very careful examination; the stems should be checked for size (see Fig. 7), and examined for signs of stretching and burning under the heads. They should also be carefully examined for cracks—the inlet valves being "Magnaflux" tested for this purpose.

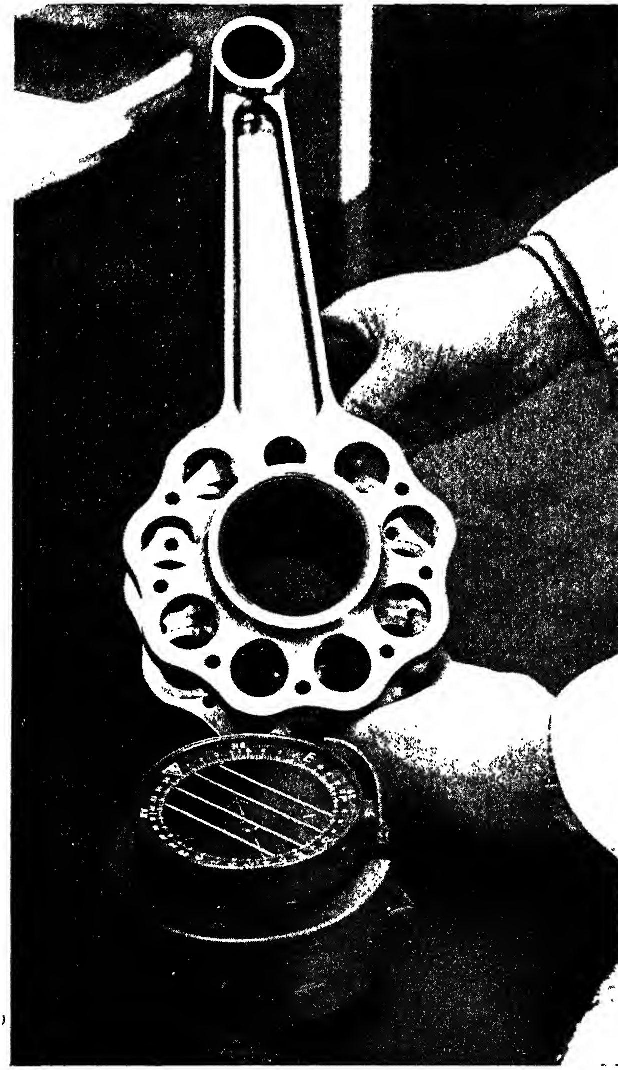

Fig. 10.—CHECKING MASTER ROD AFTER DEMAGNETISING SUBSEQUENT TO CRACK DETECTION

Stressed-steel Parts

After the engine has been fully inspected, all the stressed-steel parts should be "Magnaflux" tested for cracks, on some approved crack detector similar to that illustrated in Fig. 8. When the parts have been examined, they should be demagnetised by passing through an alternating-current loop (see Fig. 9), and finally checked against a compass or with a piece of soft iron to ensure that they have been fully demagnetised, as shown in Fig. 10.

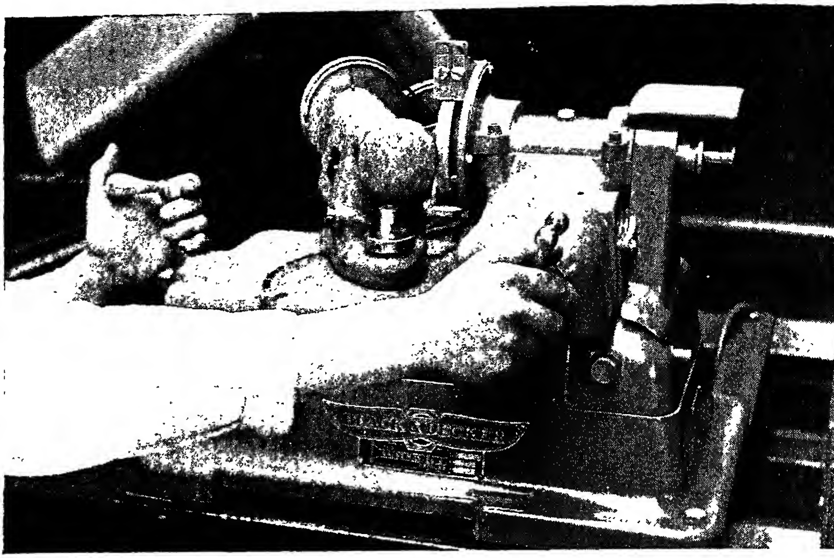

Fig. 11.—Refacing valves

RECTIFICATION AND REASSEMBLY OF THE ENGINE

After the completion of the inspection of the engine, it should be passed out for the necessary work to be carried out on it prior to reassembly. There are certain routine operations, such as the refacing of the valve seats (see Fig. 11) and the lapping of the valves into the seats in the cylinder heads, that are carried out automatically at every overhaul, and therefore there should be no need for these to be specially mentioned on the inspection sheets. Any modifications that may be required should be carried out, and all parts should then be finally checked over by an inspector before assembly is commenced.

Assembly of the engine is more or less the reverse procedure of dismantling, but there are certain checks and operations that are not carried out in the dismantling process, so an effort will be made to describe the assembly in detail, stage by stage.

Master and Link-rod Assembly

The first section of the engine to be assembled is the master and link-rod assembly. The eight articulated rods should be fitted into the master rod in their respective places, and the knuckle pins dropped into place. If any new knuckle-pin bushes have been fitted to the articulated rods, their end float in the master rod should be checked at this stage, to ensure that it is more than the minimum specified.

The knuckle pins, having been flash-tin plated to reduce the possibi-

lity of their picking up as they enter the master rod, should now be given a light coat of zinc-oxide grease, and lined up in pairs, so that when they are pressed home their heads will be in the correct position for the fitting of the lock plates.

The support posts should next be inserted between the webs of the master rod, and the pins can then be pressed home singly on an arbor press.

When all the pins are home, a check should be made that the flange of the head end of the pins is hard down on the web of the master rod. The lock plates should now be inserted. If these are not a tight fit, they should be replaced, and it may be found necessary to file the new plates to obtain the required fit.

New copper washers should be inserted under the heads of the lock-plate screws, and the pairs of screws should be wire-locked together. A final check should be made at this stage, to ensure that the correct rods and pins have been fitted in the right places, and that all locking is in place.

Crankshaft

The front section of the crankshaft should now be placed in the crankshaft assembling jig, and the rear breather-tube support and crankpin oil plug fitted in place. The fixing bolts should then be fitted into these, and the tabwashers bent up to secure them. The rear main roller bearing should be pressed on to the rear half of the crankshaft, with its oil-slinger plate behind it.

The floating counterweight should now be slipped on to the bottom of this section, after zinc-oxide grease has been generously applied inside it. Care should be taken to ensure that the side of the counterweight marked "Anti-prop End" is placed towards the rear of the engine.

The retaining spools should then be inserted through their respective holes, the counterweight retainer plate should be fitted, its two bolts inserted, and the nuts done up and split pinned.

The oil-retainer plate should then be fitted on to the front face of this section, and its four fillister-head screws done up and locked in pairs with brass locking wire.

The rear section of the crankshaft is now ready for fitting to the front section.

The master-rod assembly can now be placed on the crankpin ; the maneton should then be wiped perfectly dry, and after inserting the wedge in the top of the rear section of the crankshaft, this portion can be slipped on. The end float of the master rod on the crankshaft should then be set by the insertion of a feeler gauge of the requisite thickness between the rear face of the master rod and the shaft ; the alignment of the crankshaft should also be set by passing the aligning mandrel through the counterweight and rear crankshaft web, into the front web.

The wedge should now be withdrawn from the top of the rear section,

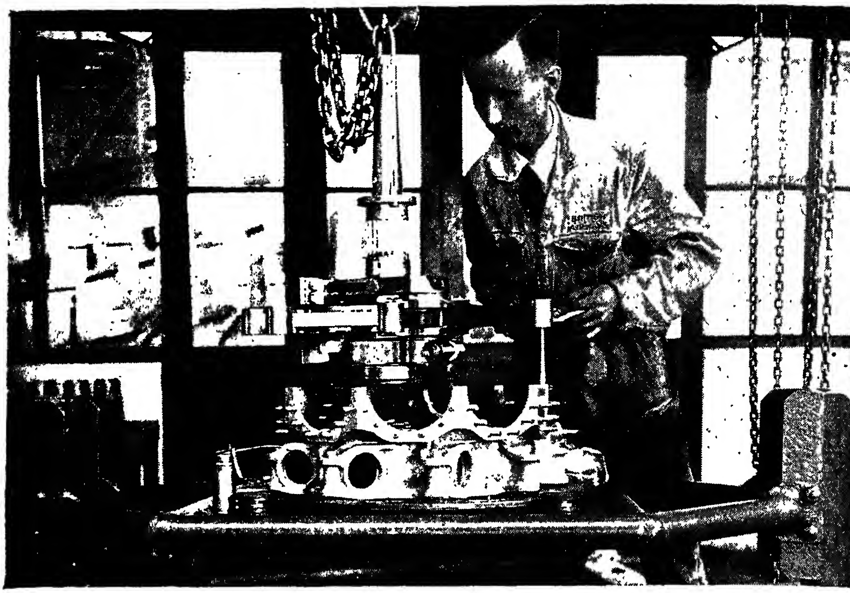

Fig. 12.—Assembling crankshaft and master rod assembly to crankcase

and the crankshaft bolt inserted. The length of the bolt should be checked with the aid of the special fitment provided, before the bolt is done up. Tension may then be applied to the bolt until the prescribed amount of stretch, as measured with a micrometer, has been obtained.

If the split-pin hole in the bolt does not line up with the hole in the crankshaft, the washer under the head on the bolt should be replaced by a thicker one, or the existing washer reduced in thickness.

The retaining nut for the rear main roller race should now be fitted and done up with the special spanner provided. Both this nut and the main crankshaft bolt may then be split pinned. A final check of the alignment of the crankshaft should be made, and the exact end float of the master rod on the crankshaft measured.

The crankshaft assembly should then be mounted on rollers or " V " blocks on a surface table, for checking the run out of the shaft. The assembly should be supported on the rear roller race and on the front race location, and the run out may then be measured with a dial test indicator, resting on the front airscrew-shaft bearing surface. This run out should be strictly within the limits laid down by the manufacturers.

Front Half of Blower Section

The front half of the blower section should now be washed off and fitted on to the engine assembly stand, being attached by at least six of the mounting lugs.

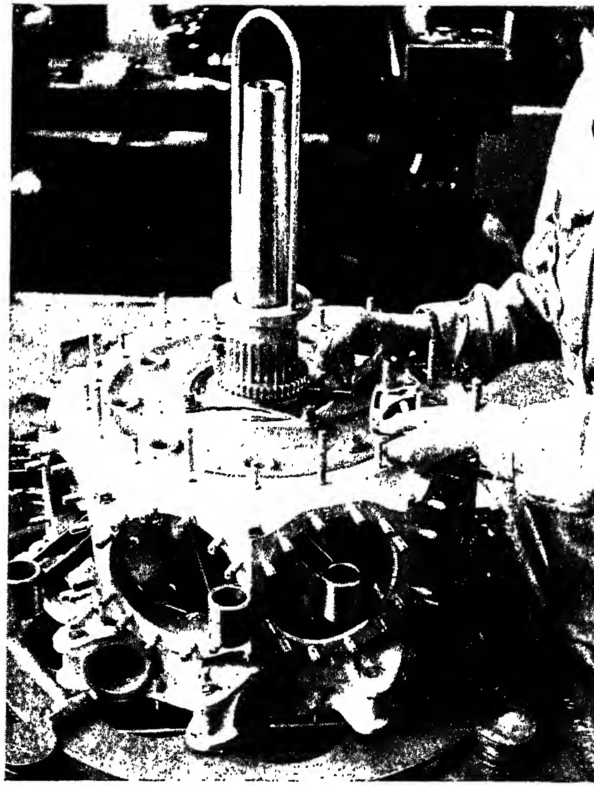

Fig. 13.—FITTING CAM REDUCTION-GEAR BRACKET

The rear half of the crankcase may also be washed off, and the bottom crankcase bolt fitted. The Empire cloth joint should then be placed on the joint face of the blower section, and the rear oil seal for the crankcase oil baffle inserted in its groove.

The rear half of the crankcase may then be lowered on to the blower section, the twenty-seven spherical washers put in place, and the nuts done up and wire locked. This assembly should then be turned over, and the Empire cloth joint under the blower shaft support inserted, followed by the support itself. This support is retained by ten countersunk screws, which are locked by staking the aluminium plate into the screw slots.

This assembly may now be turned over again, and it is ready for the fitting of the crankshaft assembly. The crankshaft lifting loop should be screwed on to the crankshaft, which can then be lifted up and lowered into the rear half of the crankcase, as shown in Fig. 12. The front half of the crankcase may now be placed in position, and the eight remaining crankcase bolts lightly tapped home. The two halves of the case may then be firmly bolted together.

Front Main Roller Bearing

The crankshaft should now be lifted in the crankcase, and firmly wedged in this position with fibre wedges. The next operation consists of tapping the front main roller bearing down into position. This should

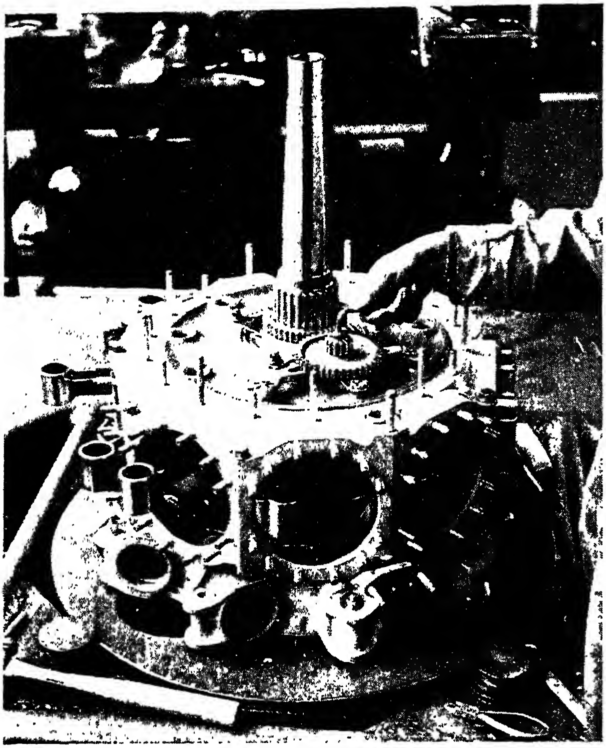

Fig. 14.—Fitting cam reduction-gear nut

be done with a sleeve fitting over the crankshaft and resting on the inner race of the bearing, and should be tapped down until the inner race is firmly home against the web of the crankshaft. The wedges may now be removed from inside the crankcase, and the cam driving gear slipped on to the shaft, with the oiling bracket beneath it.

The four locating washers should then be dropped on to their studs and the nuts may then be tightened down, thus drawing the crankshaft, by means of the front main bearing, down into its correct position in the crankcase.

Cam Reduction-gear Bracket

The cam reduction-gear bracket should now be fitted, at the same time compressing the spring on the oil tube, as shown in Fig. 13. When the bracket has been dropped into place, the spring may be released, allowing the oil tube to enter its hole in the bracket.

After the three nuts on the cam reduction-gear bracket have been done up and split-pinned, the cam reduction gear itself may be placed on its shaft, the spring and locking plug inserted in the shaft, and the nut entered in its thread. This nut should be done up by inserting an Allen wrench through the centre of the nut, and thus forcing the locking plug down and allowing the nut to turn.

When the nut is fully tightened, removal of the Allen wrench will allow the locking plug to spring up, thus locking the nut. The tightening process is illustrated in Fig. 14. Care should, of course, be taken, when fitting the cam reduction gear, to mesh the marked teeth on the large

gear with the marked tooth on the cam driving gear.

Reduction Driving Gear and Cam

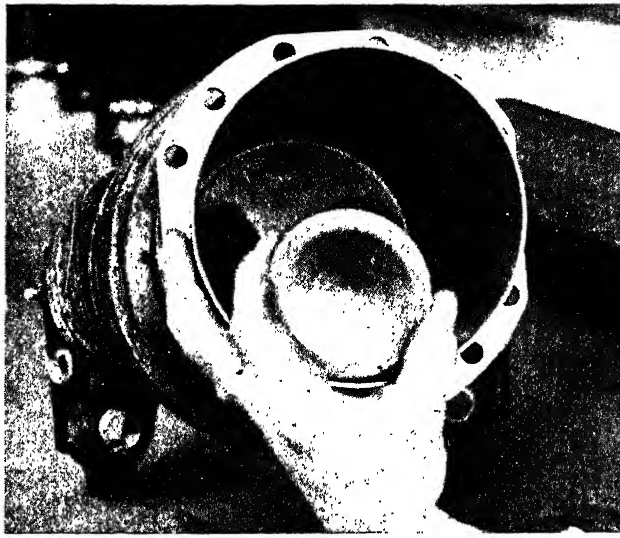

Fig. 15.—Assembly of valve in cylinder

In the next assembly operation, the reduction driving gear and the cam are fitted together. The crankshaft should be turned so that the crankpin is towards No. 1 cylinder position, and firmly wedged in this position. The reduction driving gear should be placed in an oven, the temperature of which can be accurately controlled, and heated to the temperature specified by the manufacturers. At the same time, the cam should be placed in a container full of hot oil, and warmed up in this manner.

When both these parts have reached the temperature specified, the cam thrust plate should be placed in position on the crankshaft, followed by the cam. The timing mark on the tooth of the cam reduction-gear pinion should coincide with the mark in the timing hole in the cam. The cam should be quickly centralised on the thrust plate and the reduction driving gear may then be pressed home on its splines by hand.

The retaining nut should next be spun on and done up quickly, to make sure that the gear is fully home. The gear and crankshaft should be allowed to become completely cold before the nut is finally tensioned up. When this nut has been fully tightened with the special spanner provided, the locking screw should be inserted and its head split-pinned. A final check of the valve timing should be made at this stage, to ensure that the cam did not move in the process of fitting the reduction driving gear. All wedges under the crankshaft should be withdrawn at this stage.

Assembling Cylinders

Attention should now be given to the assembling of the cylinders, prior to fitting them to the engine. After the valves and valve seats in the heads have been ground, the valves should be lapped into their

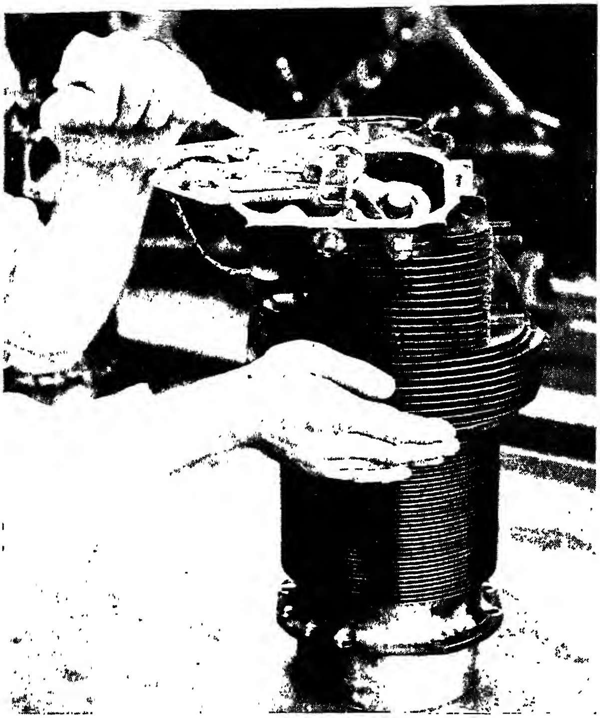

Fig. 16.—Compressing spring for assembly of collets

respective seatings with a fine lapping compound.

The inlet valves should be lapped to give a uniformly wide seating all the way round the valve ; on the exhaust valves, however, it is only necessary to obtain an even line-contact, because there is half a degree difference between the grinding angle of the valve face and that of the seat in the head.

After lapping and washing off, the valves should be assembled into the heads, and, after laying the cylinders on their front faces, the ports should be filled with petrol, to ascertain whether the lapping has been effective.

If the seatings stand up to this petrol test, the valves should be removed, and finally assembled into their guides with oil. The spring washers and springs, and finally the spring caps and collets, can then be fitted, as shown in Figs. 15, 16, and 17. The cylinders are now ready for fitting to the engine.

Piston-ring Gaps

Before the piston rings are fitted to the pistons they should be slipped into their respective cylinder barrels or into a master gauge, to ensure that the end gap of the rings is within the limits specified by the makers. If the gaps are too small, the ends of the rings should be filed carefully until the correct gap is obtained. The rings may then be fitted on to their pistons, and the side clearances of the rings in their grooves checked. If these clearances are too large or too small, oversize or undersize rings should be fitted to correct this fault.

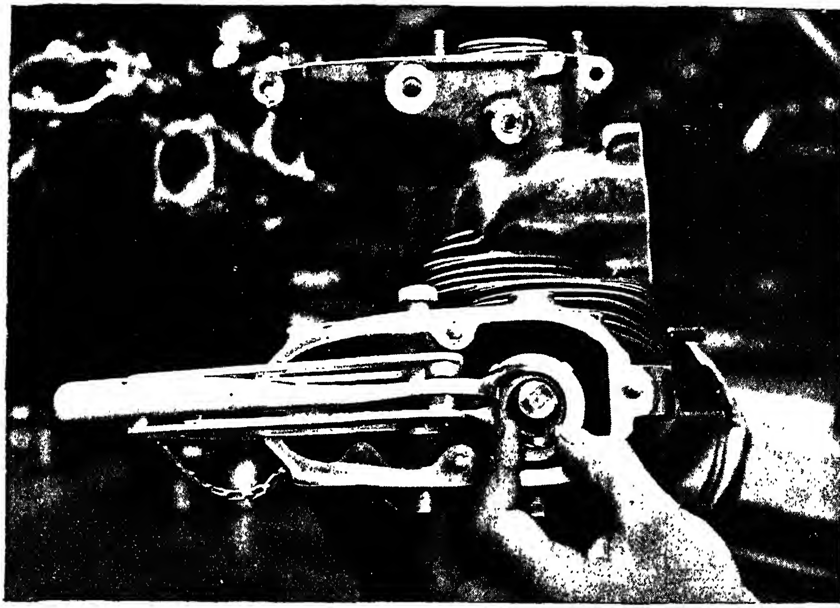

Fig. 17.—Assembly of valve collets

Prior to fitting the pistons to the engine, the rear gudgeon-pin retaining circlip should be fitted to each piston.

The first piston and cylinder to be fitted must be that which contains the master rod, i.e. No. 4 cylinder. The gudgeon pin should be pressed in by hand, as shown in Fig. 18, and the front retaining circlip then inserted in the piston. The piston and rings should then be coated with Colloidal graphite or some similar lubricant, and the gaps in the rings spaced at 120° intervals. The rubber oil-seal ring should be slipped on to the spigot of the cylinder, and the cylinder bore coated with the same lubricant as that used on the piston.

Fitting the Cylinder

The cylinder is now ready for fitting, and the special ring clamp supplied should be fitted over the piston rings and the cylinder slipped on, as shown in Fig. 19.

When the piston is completely within the cylinder, the ring clamp should be removed, and the cylinder pressed home against its flange and secured with its twelve nuts. It is most important that these nuts be tensioned up to the torque limits specified by the makers. Some form of torque-indicating wrench should be used for this purpose. The palnuts may now be installed. This procedure should be repeated until all the

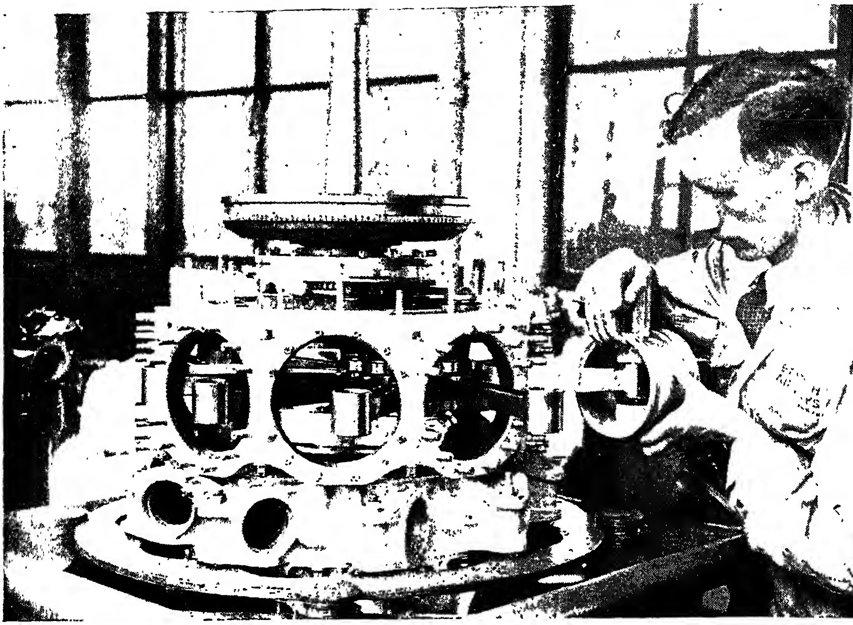

Fig. 18.—Fitting gudgeon pin in piston

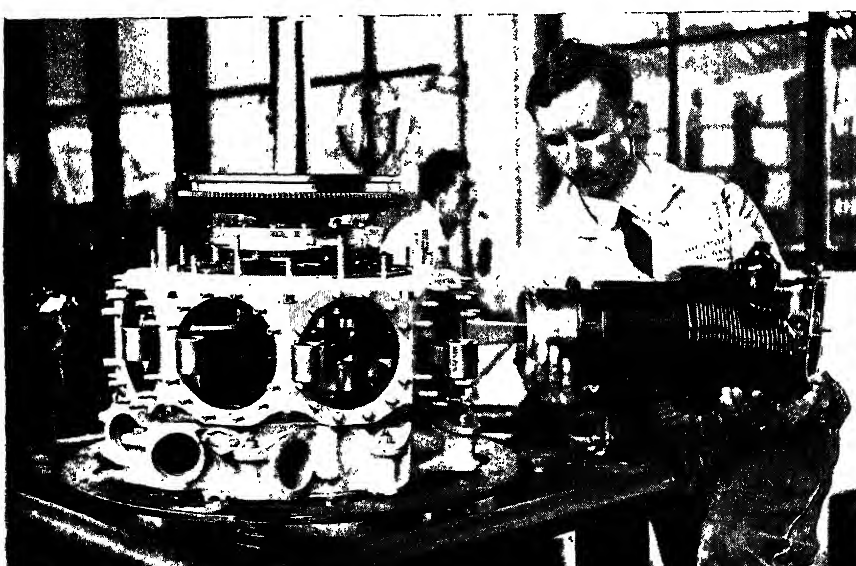

Fig. 19.—Fitting the cylinder

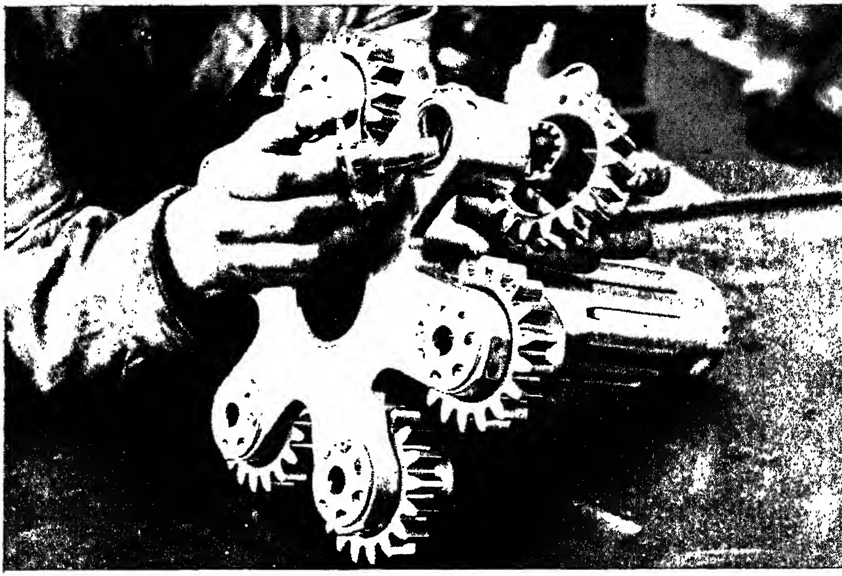

Fig. 20.—AIRSCREW SHAFT, SHOWING ASSEMBLY OF REDUCTION-GEAR PINIONS

cylinders have been fitted. The sump may now be placed in position and tightened down, the nuts being locked with palnuts.

Assembling the Nose Section

The nose section should next be assembled and fitted to the engine. The first step in the assembly of this section is the fitting of the reduction pinions into the airscrew shaft (Fig. 20). These pinions and their retaining nuts are numbered consecutively, and should be assembled to their correct positions on the airscrew shaft. The nuts which have left-hand threads should be tightened up with the special spanner provided. The pinions may be held during this operation with the bronze lock supplied, which holds two pinions stationary.

The bronze oil transfer rings which fit on the thrust bearing spacer should first be entered into the stationary gear, to check the end gap of the rings. If these gaps are too small, it is permissible to reduce the length of the ring by careful filing. These rings may then be fitted on to the spacer, and this in turn placed on the airscrew shaft.

The next operation consists of fitting the main thrust bearing into the nose section; after this has been tapped home, the stationary gear should be placed on it, and the nip of the gear flange over the bearing checked.

The stationary gear bolts may now be inserted, and after placing the oil slinger plate and front thrust plate with its gasket under it, in position on the front of the nose section, the circlips may be fitted on to these bolts.

The de-icer plate and front thrust cover may then be added, and the nuts fitted on to the bolts, done up to the required tension and locked with wire.

The nose section is now ready for the installation of the airscrew shaft. This can be most easily accomplished by placing the airscrew shaft on a block of wood, and lowering the nose section over it. The thrust nut should then be started on its thread, and screwed down slowly, entering the three oil-seal rings in the thrust plate as the nut goes home. The nut may then be tightened up with the spanner provided, holding the airscrew shaft with the turning bar.

Before fitting the nose section to the engine, the rubber sealing ring should be installed on its spigot on the crankcase. The nose section should then be lifted by the lifting eye on the front of the airscrew shaft, and, after being thoroughly oiled, should be slowly lowered into position, turning the airscrew shaft at the same time to engage the reduction-gear pinions in the driving gear.

The Breeze ignition harness should now be placed in position, and the nose-section retaining nuts may then be fitted, together with their washers, and tightened down, locking being effected with palnuts. With the ignition harness firmly attached in position, the ignition leads should be laid in their correct positions and the clamps on these leads secured under the nearest cylinder retaining nuts, and these nuts again locked.

After assembly of the tappets, pins, and rollers into their respective guides, the retaining circlets should be slipped into their grooves in the outer ends of the tappets. These tappet assemblies may then be fitted into the nose section and the retaining nuts tightened down and locked with palnuts.

The tappet springs and sockets should now be carefully placed in position ; after which the push-rod housings may be fitted complete with their joint hoses, and the hose clamps tightened. The push rods may next be inserted in their correct positions. The rocker arms, into which the adjusting sockets and clamp screws have been screwed, should now be placed in position, their bolts inserted, and the nuts tensioned up and split-pinned.

If there is excessive axial movement of any of the rocker arms in the rocker boxes, prior to tightening these nuts, a shim should be fitted to take up this clearance. Care should be taken with this operation to ensure that the end clearance of all the rocker arms, prior to tightening the rocker-shaft nuts, is within the specified limits.

The drain connection from the sump to the nose section should now be installed, and the joint hose secured with two clips.

Fitting Induction Pipes

The induction pipes may now be fitted into position. Care should be ken that the rubber glands inserted in the blower section do not ride

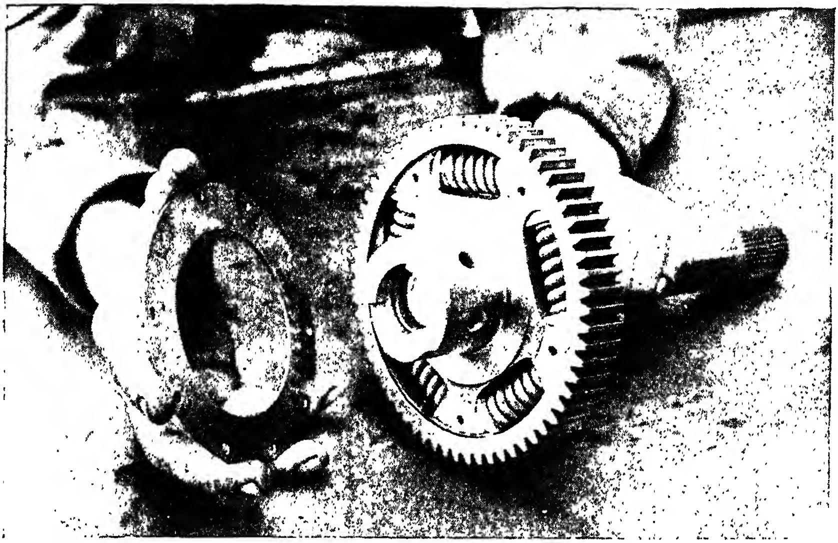

Fig. 21.—Spring drive assembly

up out of their grooves when the induction pipes are inserted through them. After the insertion of the pipes, the collars should be lightly drawn up against the flanges of the pipes at the cylinder end, and the gland nuts then started in their threads. These nuts should be tightened down hard to ensure that the glands are bottoming in their grooves, and should then be slacked back until they are just biting on the glands. If these nuts are left fully tight, it will be practically impossible to remove them at the next overhaul, due to the swelling of the rubbers in service. The collars may now be fully tightened against the cylinder-head flanges.

The inter-cylinder and cylinder-head baffles may now be fitted. The clamps which retain the inter-cylinder baffles are located between the twelfth and thirteenth fins on the cylinder barrels, counting from the head inwards. The baffles should be placed in position, the clamps fitted, the springs placed on the clamp bolts and tightened down. The baffle between Nos. 5 and 6 cylinders does not have a clamp, but is retained by a capscrew in the base of the sump and a stud and nut on the rear of the same.

The cylinder-head baffles, together with their bridge pieces, should be fitted into position with the lug on each under the top induction-pipe collar screw, and the two capscrews entered into their inserts in the head and tightened down. The heads of these screws should be wire locked to the lugs provided on the baffles. This completes the assembly of the power section of the engine, and attention should now be turned to the assembly and fitting of the supercharger section.

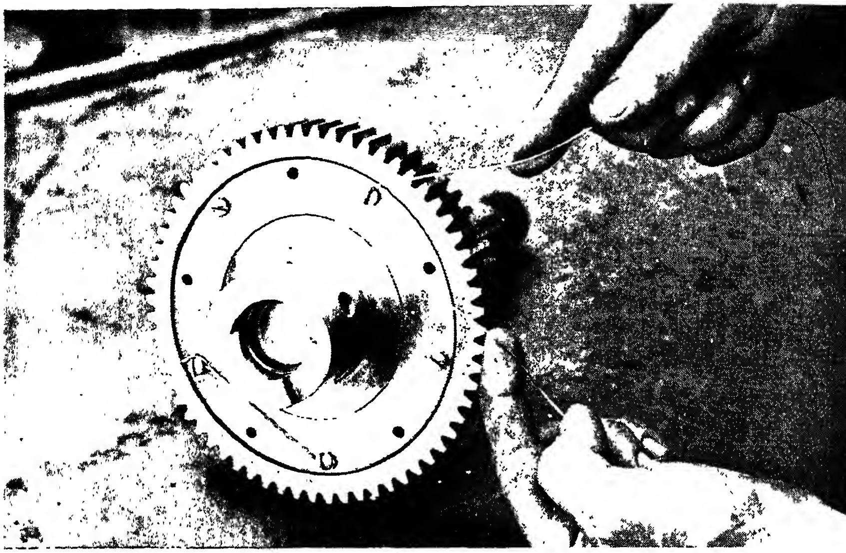

Fig. 22.—Wire locking screws on spring drive

The spring drive on the crankshaft extension shaft should first be assembled. The end pads should be placed in the springs, and after the outer gear has been placed over the extension shaft, the springs may be slightly compressed and slipped into position (see Fig. 21). The retainer plate may then be placed in position, the five fillister-head screws fitted, and these wire locked as shown in Fig. 22.

Impeller-shaft Assembly

Now the spherical thrust washer should be fitted on to the rear end of the impeller shaft, followed by the impeller-shaft retainer. The rear impeller-shaft nut may now be fitted on and tightened, and locked with a $\frac{1}{16}$-in. rivet, the end of which can be snapped down through the hole in the retainer. The rear distance sleeve, complete with its seal rings, should then be slipped on to the impeller shaft, and this latter is now ready for fitting to the blower section.

The intermediate gear of the impeller train should first be placed in position, and the impeller-shaft assembly may then be slipped in with the laminated shim under the impeller-shaft retainer. This laminated shim governs the clearance between the impeller and the blower section, and it may be necessary to remove this assembly, either to reduce the thickness, or to fit a thicker shim.

The impeller may now be pushed on to the shaft, the second spacer complete with its seal rings may then be placed in position, and the

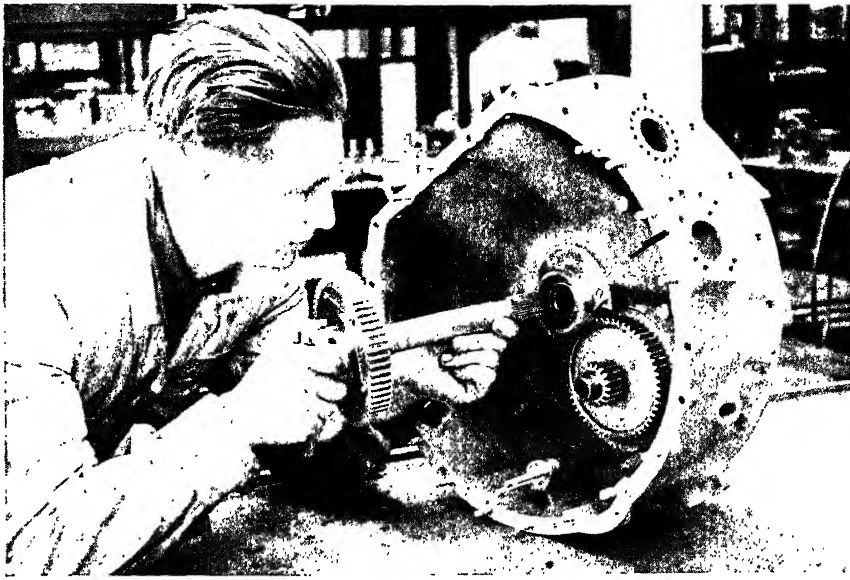

Fig. 23.—Fitting extension drive shaft

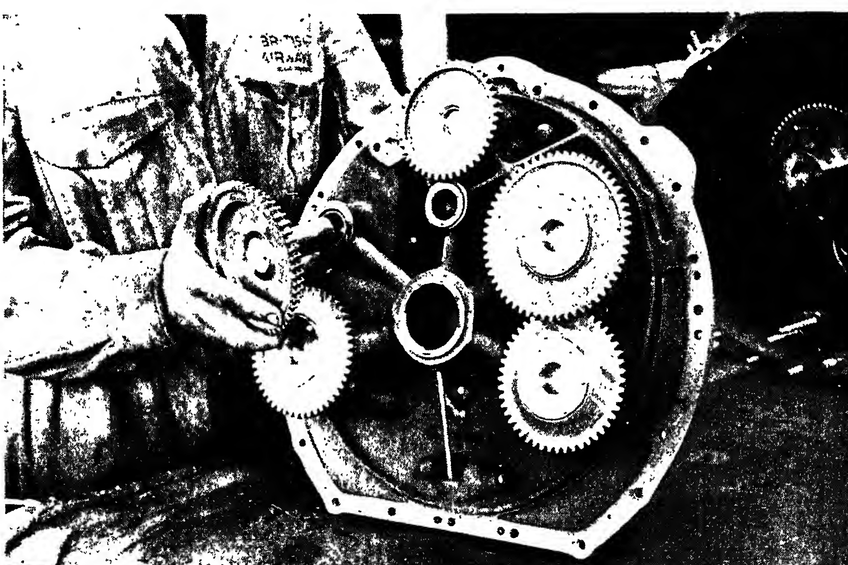

Fig. 24.—Rear cover assembly

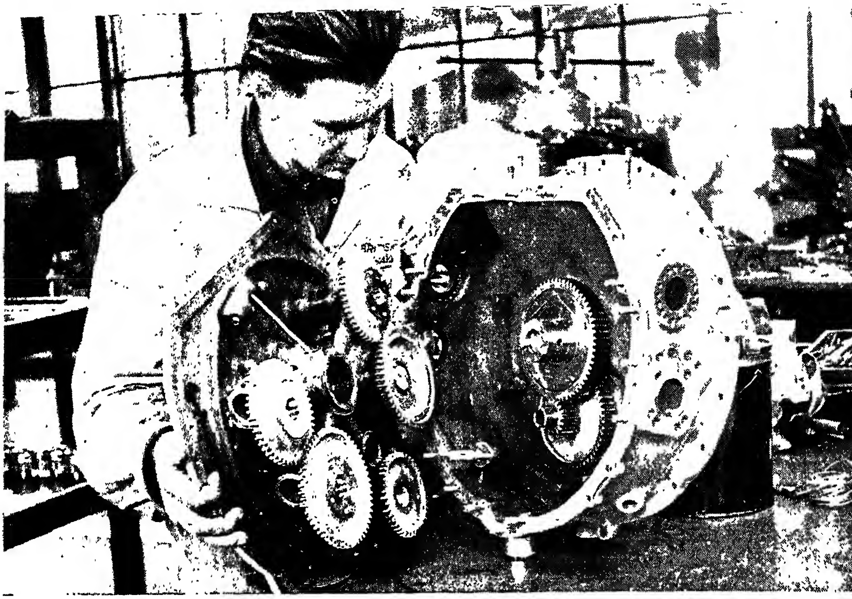

Fig. 25.—FITTING REAR COVER TO SUPERCHARGER REAR HOUSING

tabwasher and nut fitted. Three pieces of thin packing should be inserted under the impeller at this stage, to prevent its blades doing damage to the face of the blower section.

After insertion of the brass locking piece in the intermediate gear, this front impeller-shaft nut may be tightened up. The clearance between the impeller and the blower section should now be checked with three sets of feeler gauges, and if this is within the limits specified, the tabwasher on the front nut may be locked up. The crankshaft extension shaft may now be oiled and inserted through the impeller shaft, as shown in Fig. 23.

Auxiliary Drive Gears

The auxiliary drive gears may now be oiled and fitted into the rear cover, as shown in Fig. 24. After fitting the joint gasket on to the blower section, and the seal gasket on the oil suction pipe inside this section, the rear cover may be fitted on to the blower section as shown in Fig. 25.

When all the nuts and palnuts have been fitted and tightened, the auxiliary drive gearbox should be fitted into position, the gears placed in and the cover fitted on and tightened down (see Fig. 26).

The tachometer drive gearbox may next be assembled and fitted on to the side of the blower section, and, after the fitting of the blanking

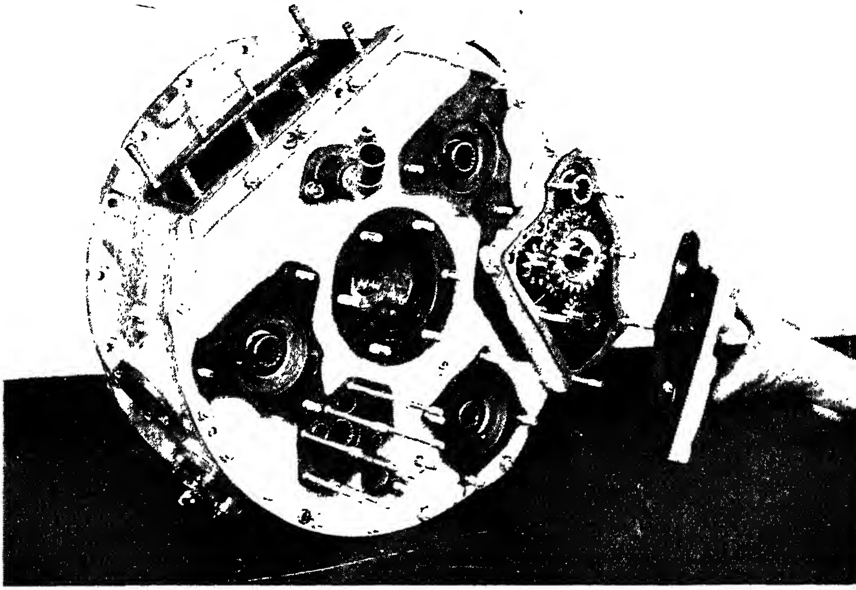

Fig. 26.—Dual accessory drive assembly

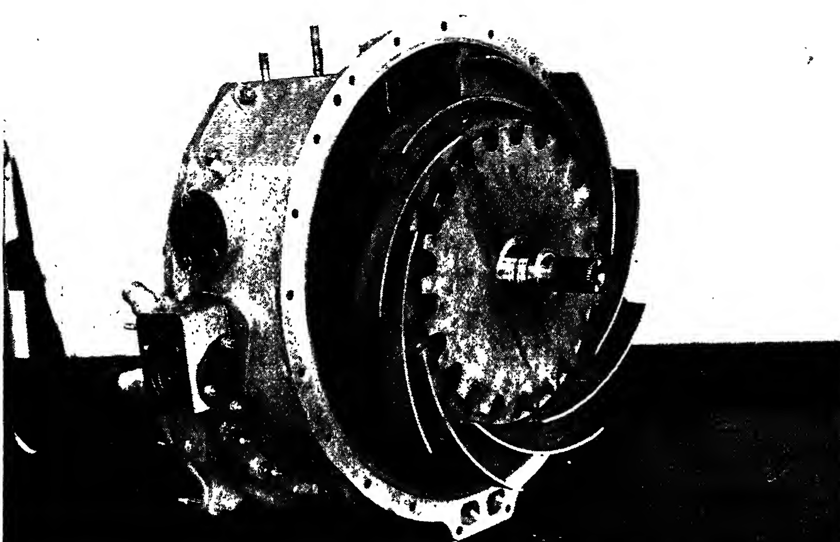

Fig. 27.—Front of supercharger housing showing impeller and drive shaft

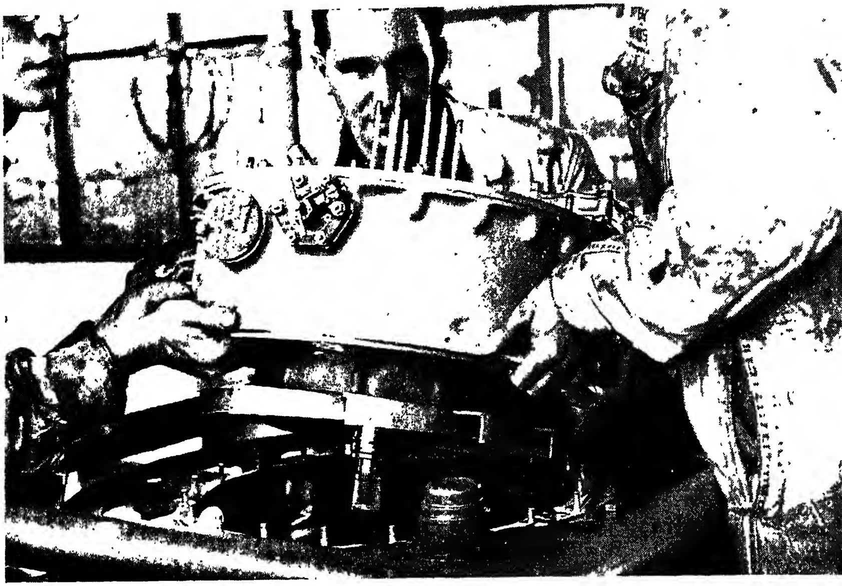

Fig. 28.—ASSEMBLY OF REAR SUPERCHARGER HOUSING TO FRONT HOUSING AND CRANKCASE

plates in the gun sychroniser drive holes, and the Cuno oil filter, the blower section is complete and ready for fitting on to the engine (see Fig. 27).

The blower section may now be lowered into position, as shown in Fig. 28. Care should be taken in this operation to see that the blower section is entered square, so that there is no possibility of catching the seal rings on the impeller shaft on their sleeve as they go down. The blower section nuts should now be tightened down and the palnuts fitted.

At this stage a blanking plate should be fitted over the carburettor intake to prevent any dirt or other foreign matter from entering the blower section. The oil pump, which is shown laid out in Fig. 29 may now be assembled and fitted on to the rear cover, and the nuts wire locked.

Magnetos

The magnetos should now be prepared for fitting to the engine. First, the contact breakers should be removed and some insulating medium placed between the contact-breaker pickup shoe and the plate on which it bears. The engine should be turned until it is at the magneto firing point, as indicated by the markings on the outer rim of the reduction driving gear, which can be seen through the timing hole on the port side of the nose section. The magneto should now be rotated until the

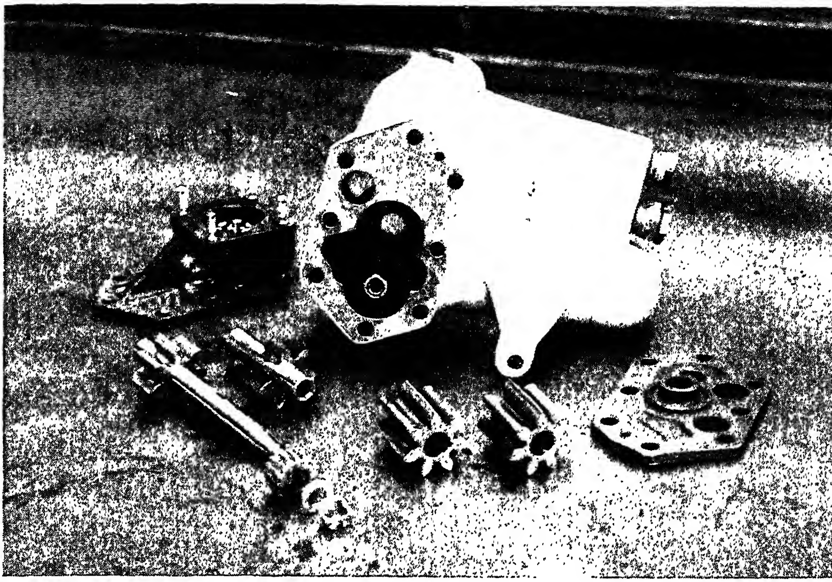

Fig. 29.—Components of the oil pump

timing marks on the distributor driving gear coincide with the marks on the housing.

Now the magneto may be fitted on to the engine, and its timing checked after tightening down the retaining nuts. A lamp and battery should be used for this purpose, one lead of which should be earthed and the other connected to the insulated contact-breaker point. Fine adjustment of this timing may be effected by slacking off the retaining nuts allowing the magneto to be turned, the holes in the magneto flanges being slotted for this purpose. When the magneto has been correctly timed, the retaining nuts may be locked with brass wire.

The second magneto should be fitted and timed in the same manner, and a final check made to ensure that the magnetos are synchronised. The contact breakers should then be removed to allow the withdrawal of the pieces of insulating material mentioned above.

The ignition wires should next be inserted in the distributor blocks of the magnetos. Each lead should be traced through from the end which fits into the sparking plug, and should be cut off to the required length to fit snugly into its appropriate hole in the distributor block. The leads should then be entered in their respective holes and the staking screws tightened down.

Care should be taken to see that the leads are entered in their correct holes, bearing in mind the fact that the numbers on the distributor blocks refer to the order in which the sparks are delivered by the distributor.

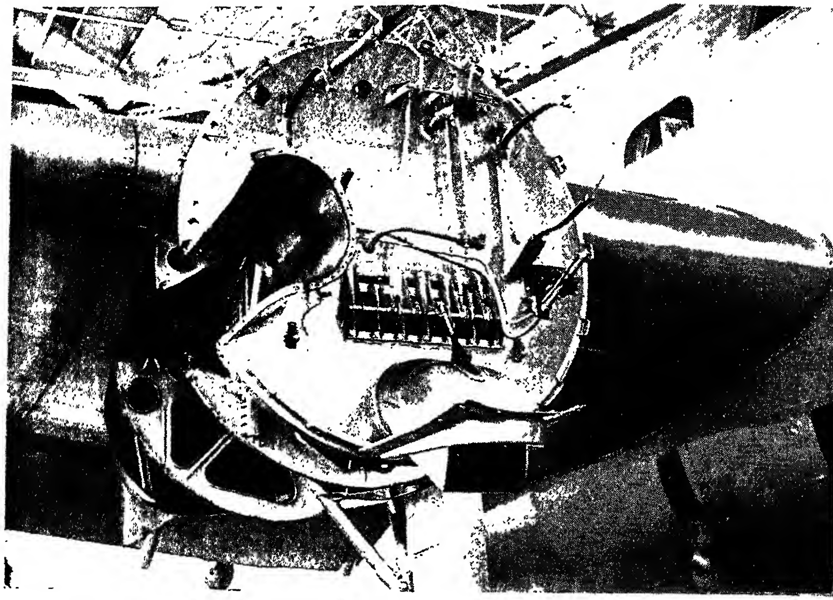

Fig. 30.—The engine firewall

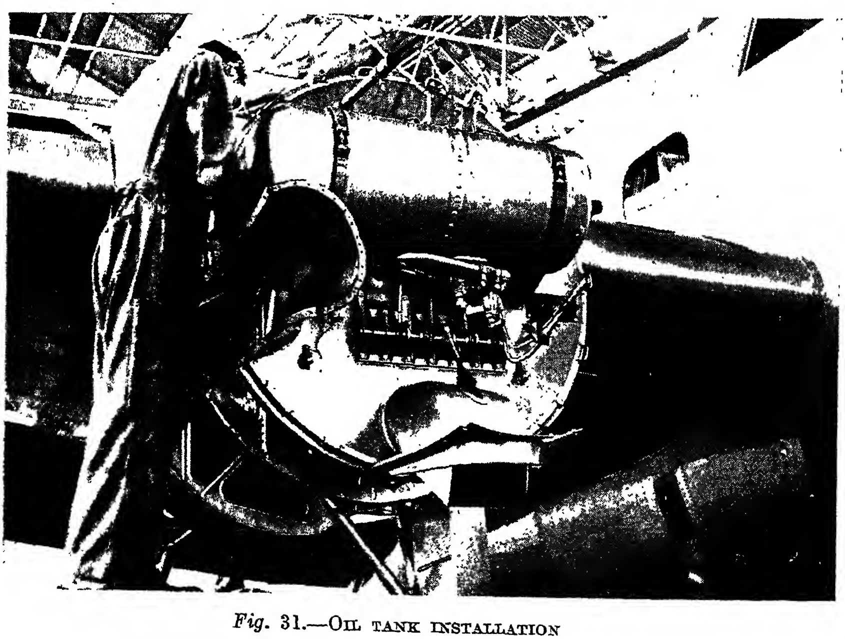

Fig. 31.—Oil tank installation

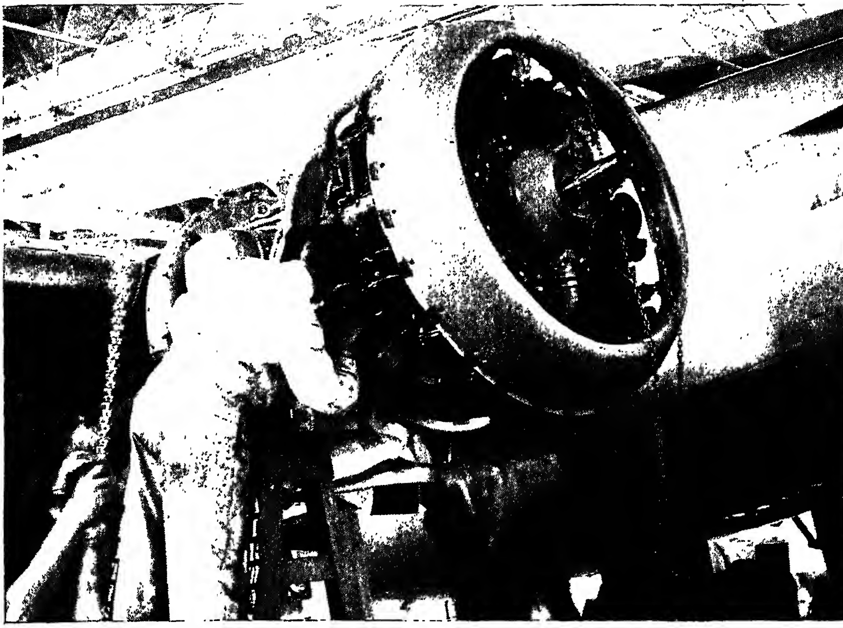

Fig. 32.—Installing an engine assembly in starboard mounting

After all the leads have been fitted, the distributor shields should be placed in position and secured by their retaining clips and screws.

The engine may now be turned up on its back, i.e. with the airscrew shaft vertical, and the tappet clearances adjusted with the special feeler gauge provided. These can all be adjusted in one complete cycle i.e. two revolutions of the engine, and it is then necessary to complete three more cycles of the engine, checking every clearance to ensure that none of the clearances are too small, due to irregularities of the cam. The rocker-box covers may now be fitted and tightened down.

The engine is now complete and, after the fitting of a starter and generator and the blanking off of all the other accessory drive positions, is ready for transfer to the test bench.

Testing

Testing the engine should be carried out in accordance with the makers' recommendations. After the completion of the tests, the engine will be returned to the shop, when the sump should be drained, the filters checked for any traces of metal, and all final locking carried out. The tappet clearances should again be checked to ensure that no great alteration has occurred. The rocker-box covers may then be replaced, and, after the engine has been thoroughly washed down, a final check should

Fig. 33.—Mounting the airscrew on to the shaft

be made to ascertain whether all final locking has been correctly carried out and that everything is in order.

PREPARING THE ENGINE FOR INSTALLATION

The engine is now ready for building up into its installation, and the first step in this process is to lift the engine with the necessary tackle out of the engine stand and secure it in the engine mounting ring with nine bolts through the lugs on the blower section. All accessories, such as constant-speed governor, vacuum pump, hydraulic pump, etc., and the carburettor may now be installed. The electrical harness and all pipe connections to the accessories should next be fitted. The nose ring of the cowling and the exhaust ring should be installed at the same time—this latter including the front section of the exhaust tail pipe. When the building up of the installation has been completed, it should be carefully inspected to ensure that all locking is present and correct.

Before the engine is re-installed in the aeroplane, the oil tank should be removed for cleaning, and the firewall thoroughly washed down (see Fig. 30). The oil tank should then be replaced and the turnbuckles in the tank straps locked (see Fig. 31).

The engine installation may now be released from its building stand and lifted up so that the four arms of the bearer frame engage the four lugs on the firewall, allowing the main bearer bolts to be inserted. After the nuts have been fitted to these bolts, tightened up and split-pinned,

Fig. 34.—SYNCHRONISING BLADES BEFORE ASSEMBLING DOME

Fig. 35.—ASSEMBLY OF DOME

the lifting tackle and spreader bar may be removed and the rocker-shaft nuts to which the tackle was attached, split-pinned. All connections of controls, pipe lines, and Cannon plugs should now be made good at the firewall, and the exhaust tail pipe fitted.

The airscrew may next be installed (see Fig. 33) after coating the airscrew shaft with Whitmore's compound and sliding on the rear cone. Now the airscrew retaining nut may be entered on its thread and tightened up with the special spanner provided. This nut should be pulled up very firmly, and care should be taken to see that one of the locking holes in the nut coincides with one of the holes in the end of the airscrew shaft.

The distributor valve assembly should next be installed and tightened up with its special spanner. When this has been fully tightened, inspection should be made to see that one of the locking grooves coincides with the aligned locking hole in the end of the airscrew shaft. If this is correct, the special locking wire may be inserted through the hole in the nut and sprung into its groove.

The airscrew blades should now be turned by hand to the fully feathered position as shown in Fig. 34. The dome assembly—the gear of which has been turned to the fully feathered position by forcing the piston forward to its full extent—may now be offered up as shown in Fig. 35, and the nut securing the dome within the barrel tightened and locked with the screw provided. The front dome nut may now be installed and locked with its spring lock wire.

A final inspection should now be carried out to make sure that everything has been correctly connected, that the airscrew blades have been turned by hand to the fully fine pitched position and that the oil tank has been filled.

The engine may now be started up and, after warming, may be fully run up to check the functioning of all the engine instruments and to check the ground performance of the engine. If everything is in order, the remaining engine cowlings should be fitted and the aeroplane is then ready for a test flight, prior to being placed on service.

MAINTENANCE AND OPERATION OF BRISTOL AERO ENGINES

BRISTOL engines of the poppet-valve and sleeve-valve types are to be found in a variety of military and civil aircraft, which include aeroplanes and flying boats. The "Mercury" and "Pegasus" poppet-valve engines and the "Perseus" sleeve-valve are air-cooled nine-cylinder radial engines. The fundamental difference between the two types of engine is to be found in the front half of the crankcase and the cylinder assembly, the valve system of the "Mercury" and "Pegasus," consisting of cam wheel, push rods, rocker gear, and poppet valves, gives place to nine small right-angle cranks driven at half engine speed through a gear train from the crankshaft. Each crank, which has its bearing in the wall of the front half of the crankcase, engages through a ball-and-socket joint with the lower end of the sleeve. Rotation of the sleeve-drive cranks gives an up-and-down and slightly rotary motion to the sleeve, which is thus enabled to cover and uncover the inlet and exhaust parts in the cylinder barrel according to the usual four-stroke principle.

The cylinder head or junk head projects into the top of the sleeve, forming a gastight seal.

The cylinder assembly then, with the sparking plugs in the cylinder head, is simpler to inspect and maintain than the counterpart of the poppet-valve engine with its many parts needing adjustment. Other parts of the two types of engines generally are similar.

Leading Particulars of Poppet-valve and Sleeve-valve Engines

The leading particulars are given in Tables I to III; poppet-valve engines, "Pegasus," Table I, and "Mercury," Table II; sleeve-valve engines, "Hercules," "Taurus," "Perseus," and "Aquila," Table III, and photographs of each appear in Figs. 1 to 6.

Operation

The operation of the poppet-valve and sleeve-valve engines is similar in many respects, and will be dealt with as noted below; where there are differences between the "Mercury," "Pegasus," and "Perseus" engines, these will be indicated.

1. Procedure for inspecting an engine which is new or has not been in use for a long time.

TABLE I.—PARTICULARS OF THE "PEGASUS" ENGINES

Engine Type	*Maximum Take-off Power B.H.P.*	*International Rated Power B.H.P.*	*Max. Power for All-out Level Flight (5 mins.) B.H.P.*	*Cubic Capacity*	*Overall Diameter*	*Airscrew Reduction Gear Ratio*
"PEGASUS Xc" Civil Rated	920	710/740 at 3,500 ft. (1,070 m.)	830 at 5,250 ft. (1,600 m.)	1,753 cu. in. (28·7 litres)	55·3 in. (1·405 m.)	0·500
"PEGASUS XVII & XVIII" Two-speed Supercharged	965	780/815 at 4,750 ft. (1,450 m.) 720/750 at 14,750 ft. (4,500 m.)	1,000 at 3,000 ft. (915 m.) 885 at 15,500 ft. (4,730 m.)	1,753 cu. in. (28·7 litres)	55·3 in. (1·405 m.)	XVII : 0·572 XVIII : 0·500
"PEGASUS XIX & XX" Fully Supercharged	835	800/835 at 8,500 ft. (2,600 m.)	925 at 10,000 ft. (3,050 m.)	1,753 cu. in. (28·7 litres)	55·3 in. (1·405 m.)	XIX : 0·572 XX : 0·500
"PEGASUS XXII & XXIII" Medium Supercharged	1,010	800/840 at 4,000 ft. (1,220 m.)	830 at 6,500 ft. (1,980 m.)	1,753 cu. in. (28·7 litres)	55·3 in. (1·405 m.)	XXII : 0·500 XXIII : 0·572
"PEGASUS XXV & XXVII" Fully Supercharged	830	795/830 at 11,000 ft. (3,360 m.)	915 at 9,500 ft. (2,900 m.)	1,753 cu. in. (28·7 litres)	55·3 in. (1·405 m.)	XXV : 0·500 XXVII : 0·572

TABLE II.—PARTICULARS OF THE "MERCURY" ENGINES

Engine Type	*Maximum Take-off Power B.H.P.*	*International Rated Power B.H.P.*	*Maximum Power for All-out Level Flight (5 mins.) B.H.P.*	*Cubic Capacity*	*Overall Diameter*	*Airscrew Reduction Gear Ratio*
"MERCURY VIII & IX" Fully Supercharged	725	795/825 at 13,000 ft. (3,960 m.)	840 at 14,000 ft. (4,265 m.)	1,520 cu. in. (24·9 litres)	51·5 in. (1·307 m.)	VIII : 0·572 IXX : 0·500
"MERCURY XI & XII" Medium Supercharged	830	780/820 at 3,500 ft. 1,070 m.)	890 at 6,000 ft. (1,830 m.)	1,520 cu. in. (24·9 litres)	51·5 in. (1·307 m.)	I : 0·572 XII : 0·500

2. Procedure for inspecting an engine which is in regular operation.
3. Procedure for starting the engines.
4. Running the engines.
5. Engine ground test, taking off, climbing, and in flight ("Mercury" and "Pegasus").
6. Engine ground test, taking off, climbing, and in flight ("Perseus").
7. Routine maintenance.

PROCEDURE FOR INSPECTING AN ENGINE WHICH HAS BEEN NEWLY INSTALLED, OVERHAULED, OR OUT OF USE FOR A LONG TIME

Any differences between poppet-valve and sleeve-valve types will be indicated, otherwise the procedure is similar for both.

(1) Examine the tightness of all main external nuts, bolts, etc., on the engine and mounting, and see that they are tight and properly locked.

(2) Operate all engine and magneto controls to see that they work freely, and ensure that the full range of movement is available on the throttle, etc. It is important to examine the control-mechanism pins, and to see that they are properly secured with split pins.

(3) Check the track of the airscrew blades, and ensure that the airscrew is tight on its hub and that the hub is tight on the airscrew shaft. Ensure that the locking devices of the airscrew shaft nut are in position and secure. To check the track of the blades, the aeroplane should be set with its datum line level and, if possible, the load taken off the

TABLE III.—PARTICULARS OF THE SLEEVE-VALVE ENGINES

Engine Type	*Maximum Take-off Power B.H.P.*	*International Rated Power B.H.P.*	*Max. Power for All-out Level Flight (5 mins.) B.H.P.*	*Cubic Capacity*	*Overall Diameter*	*Airscrew Reduction Gear Ratio*
"HERCULES II" Medium Supercharged	1,290	1,100/1,150 at 5,000 ft. (1,520 m.)	1,375 at 4,000 ft. (1,220 m.)	2,360 cu. in. (38·7 litres)	52·0 in. (1·32 m.)	0·444
"TAURUS" Medium Supercharged	1,010	860/900 at 5,000 ft. (1,520 m.)	1,065 at 5,000 ft. (1,520 m.)	1,550 cu. in. (25·4 litres)	46·25 in. (1·175 m.)	0·444
"PERSEUS X" Fully Supercharged	750	700/730 at 14,500 ft. (4,420 m.)	880 at 15,500 ft. (4,730 m.)	1,520 cu. in. (24·9 litres)	52·0 in. (1·32 m.)	0·500
"PERSEUS XI & XII" Medium Supercharged	830	715/745 at 6,500 ft. (1,980 m.)	905 at 6,500 ft. (1,980 m.)	1,520 cu. in. (24·9 litres)	52·0 in. (1·32 m.)	XI : 0·572 XII : 0·500
"PERSEUS XIIc"	890	680/710 at 4,000 ft. (1,220 m.)	815 at 6,000 ft. (1,830 m.)	1,520 cu. in. (24·9 litres)	52·0 in. (1·32 m.)	0·500
"AQUILA IV" Civil Rated	600	450/470 at 4,500 ft. (1,370 m.)	540 at 6,000 ft. (1,830 m.)	950 cu. in. (15·6 litres)	46·0 in. (1·168 m.)	0·500

undercarriage by jacking up the fuselage; chocks should be placed at the front and at the rear of each wheel.

With one sparking plug removed from each cylinder to facilitate turning the engine, position the airscrew so that one blade is vertical and below the engine centre line. Behind the airscrew place a rigid box or trestle, and on it fix a pointer in such a position that it just touches the trailing edge of the blade at approximately three-quarter blade radius. Turn the airscrew so that the next blade passes the pointer and measure the difference. Rotate the airscrew by holding near the hub and not at the blade tip, and take care not to disturb or rock the aeroplane.

The maximum variation in blade track should not exceed 0·100 in. when measured at not less than 5 ft. radius. As an additional precaution the tracking tests should be repeated on the front sides of the airscrew on the highest camber.

(4) If a de Havilland Hamilton variable-pitch airscrew is fitted it should be checked for tightness on the airscrew shaft in the following manner. Remove the locking ring and unscrew the cylinder head, using the spanner provided. Disengage the piston-locking ring by removing the split pins and, using the same spanner, check the tightness of the piston. The applied tightening moment should be in the region of 800 ft.-lb., or in other words, it is satisfactory to apply a force of from 250 to 300 lb. at the end of a 3-ft. bar.

To ensure that the hub is pulled home, the bar should be given one smart blow on the section closest to the hub, using a hammer weighing not more than 2½ lb. and with a normal swing, the weight meanwhile being suspended on the end of the bar. Do not attempt to tighten the piston by hammering on the end of the bar. After tightening, secure the piston with the lock ring and fit new $\frac{3}{32}$-in. split pins, two or three as required, to prevent movement. Fit the cylinder-head gasket, taking care that it rests squarely on the cylinder head; the gasket should be held in position with a thin coating of approved grease. Replace the cylinder head, tighten with the spanner, and finally secure it with the locking ring.

(5) Remove all the sparking plugs, rotate the engine, and watch for signs of oil flooding in the lower cylinders. If signs are observed, continue to turn the engine until all surplus oil is drained out. Clean all the sparking plugs and see that the gaps are correctly set to 0·012 in.–0·015 in. Where facilities are available test the plugs under pressure on a testing rig.

(6) Check the clearances on all valves and, where necessary, readjust (applies only to poppet-valve engines).

(7) When replacing sparking plugs, ensure a satisfactory gas seal by removing any carboned graphite from plug seats; smear the threads of the plugs lightly with a mixture of graphite and grease, and fit new washers

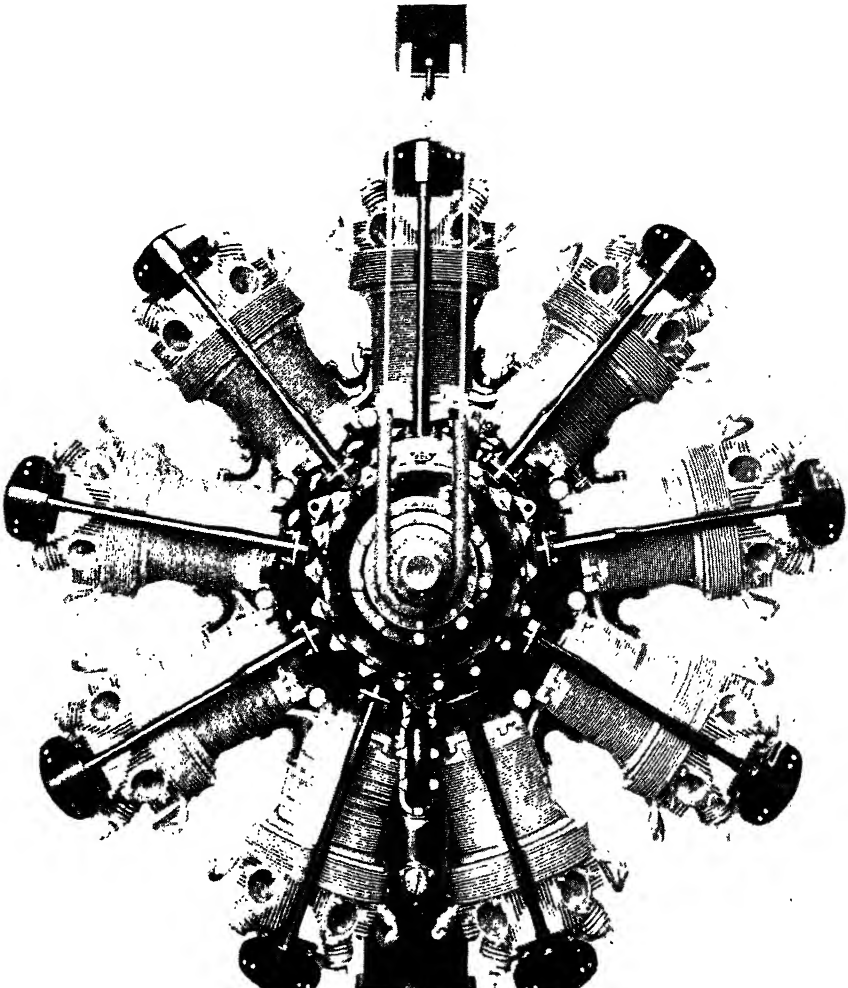

Fig. 1.—"PEGASUS" ENGINE

of the rolled-copper type. Make sure that the sparking plugs are securely screwed down, as any gas leakage will not only corrode the sparking-plug threads, but will increase the cylinder temperature. Before assembling the H.T. connections, ensure that they are clean and free from foreign matter.

(8) Inspect the fuel pipes and system. Drain the tanks and flush out with clean petrol; clean the filters, replace and lock. Ensure that all

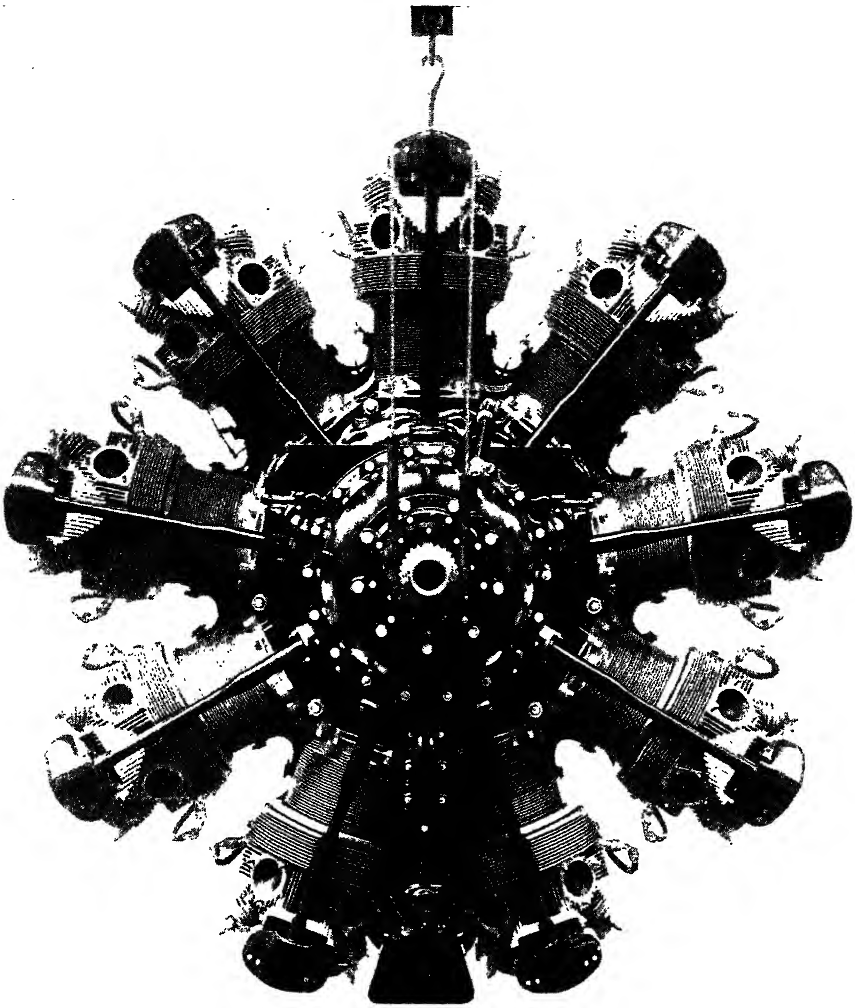

Fig. 2.—"MERCURY" ENGINE

unions are safely locked, and fill the tanks with approved fuel, which must be clean and free from water.

(9) Inspect all pipe joints in the oil system, see that the clips are secure, and that the rubber hose connections are neither damaged nor perished. Withdraw the rear-cover oil-filter, and thoroughly clean with a stiff brush and paraffin. After replacement ensure that the filter cap is securely locked.

Drain the oil tanks and flush out with paraffin or petrol. If, however, paraffin is used, the tanks should afterwards be flushed out with petrol, finally making sure that all the petrol is drained away.

Replenish the tanks, giving at least the specified minimum oil allowance.

If an oil shut-off cock is fitted, see that it is locked in the fully open position.

Magneto

(10) Inspect the magneto contact breakers, check the rocker arms for freedom, and see that the points are set to the correct gap (0·011 in.–0·013 in.) and are not pitted. Remove the magneto distributors, ensure that they are scrupulously clean, and that the spring-loaded starter brush is making good contact on the centre of the distributor rotor.

(11) If the engine has been standing for longer than 48 hours in an air temperature of about 5° C. or overnight in air temperatures of 0° C. and below, it is necessary to prime the blower bearings and the lubrication system with oil as follows :

Blower Bearings

(*a*) Inject two pumps full of warm engine oil through the priming nipple on the engine rear cover, using the oil gun provided.

(*b*) Inject two pumpfuls of warm engine oil through the nipple on the crankcase.

(*c*) Turn the crankshaft through three or four revolutions immediately afterwards to distribute the oil.

Lubricating System

(*a*) Inject half a gallon of hot engine oil (50° C.) through the pressure-gauge connection on the rear cover.

(*b*) Use a pressure of between 10 and 60 lb. per square inch. In no circumstances use cold oil or a pressure less than 10 lb. per square inch, as there would then be a danger that the oil would not reach the more remote bearings.

(*c*) If the engine is fitted with a variable-pitch airscrew control valve, ensure that it is closed, i.e. in the coarse pitch position, during the priming operation, so as to prevent oil escaping into the variable-pitch oil circuit.

(*d*) Refit the pressure-gauge connection and lock. If atmospheric temperature conditions have been such as to necessitate the foregoing oil priming, the lapse of time between priming and running the engine should not exceed four hours, otherwise the priming operation will be rendered ineffective.

As the oil used for priming will subsequently come into circulation, it is of the utmost importance to ensure that the pump employed for

priming the engine, also the oil gun for priming the blower bearings, is thoroughly washed with petrol before use, and that only clean filtered engine oil of an approved brand is used.

(12) If the engine is fitted with a variable-pitch airscrew, inspect the oil-supply pipes and see that the joints are satisfactory.

(13) Charge the valve-rocker bearings with approved grease through the right-angled nipple on the rear of each rocker bracket, using the grease gun provided. Continue to inject grease until it just oozes from around the bearings; wipe away the surplus. Also grease the rocker-adjusting screws by means of the appropriate gun (applies only to poppet valve).

Rocker Mechanism Felt Lubricating Pads

The rocker mechanism felt pads should not normally require re-soaking until the 120-hour routine inspection period. If, however, the aeroplane is operated spasmodically and the period of time elapsing between each 120-hour inspection exceeds one month, the felt pads should be soaked every month in order to counteract the normal drying of the felt (applies only to poppet valve).

PROCEDURE FOR INSPECTING AN ENGINE WHICH IS IN REGULAR OPERATION

When the engine concerned is in constant and regular use, the following general inspection procedure should be carried out:

(1) Ensure that sufficient fuel of the correct grade is in the tank. These engines are designed to operate on fuel to Air Ministry Specification D.T.D. 230 (87 octane).

(2) Ensure that the oil tank contains an adequate supply of lubricating oil of an approved brand. Give a minimum oil allowance of 12 pints for each hour's fuel supply carried, and do not run the engine with less than 2 gallons in the tank.

(3) Remove and clean the bottom sparking plugs in cylinders Nos. 4, 5, 6, and 7. This is important, as, owing to the inclination of these lower cylinders, any condensation or oil present tends to drain on to the sparking plugs.

(4) See that the main oil cock, if fitted, is locked in the open position. On the majority of modern installations, however, the oil cock is not fitted; a spring-loaded check valve is included in the engine oil pump, which prevents flooding of the engine whilst standing idle.

(5) See that all cowling panels are secure, and that no tools or cleaning rags, etc., have been left on the engine or mounting.

(6) If the engine has been standing for longer than 48 hours in an air temperature of about 5° C. or overnight in air temperatures of 0° C. and below, it is necessary to prime the blower bearings and the lubrication system with oil, as described in paragraph 11, page 44.

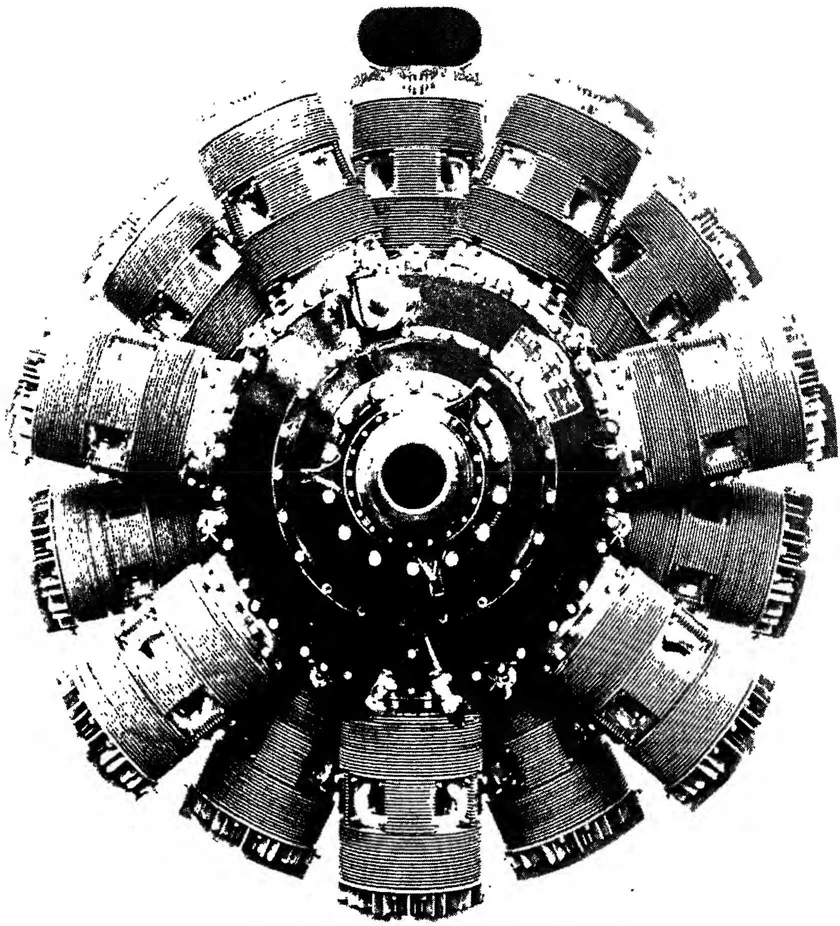

Fig. 3.—"HERCULES" ENGINE

PROCEDURE FOR STARTING THE ENGINES

There are four types of starters; the first three are usually fitted, but the fourth is now used as well:

(1) Combined hand or electrically operated direct turning-gear unit. Rotax, Type E.160.

(2) Hand-operated inertia starter unit. Rotax, Type XI.

(3) Combined hand or electrically operated inertia starter unit. Rotax, Type XI.

(4) In some of the later "Perseus" installations the Coffman combustion starter is fitted.

(1) **Starting with Hand or Electric Turning Gear**

Hand Turning Gear.—(*a*) See that starter magneto and main magneto switches are in the OFF position.

(*b*) Set the fuel cocks in the ON position, and also turn on the fuel cock to the priming system.

(*c*) Place the starter handle in position.

(*d*) Set the mixture control in the normal position, open the throttle fully, and bring back along the quadrant until very nearly closed.

(*e*) If a V.P. airscrew is fitted, set the control in the fine pitch (take-off) position.

(*f*) Set the air intake heat control to the position for admitting cold air.

(*g*) If the installation concerned is provided with controllable cowling gills, these should be set in the fully open position.

(*h*) Place the starter and main magneto switches in the ON position.

(*i*) Operate the primer pump until the suction pipe and pump are primed with fuel, as indicated by the "feel" of the plunger.

(*j*) Rotate the engine by means of the turning gear, and at the same time operate the primer pump to inject approximately six to eight pumpfuls of fuel into the priming system. The amount of priming quoted throughout the starting procedure is the average for normal climatic conditions, and may need to be increased in cold weather or decreased in hot weather.

(*k*) Continue turning the engine and at the same time crank the hand-starter magneto vigorously until the engine starts. On certain installations the starter magneto may be interconnected with the turning gear or inertia starter, in which case it will not, of course, be turned by hand. With this arrangement do not switch on the starter magneto until the engine has completed approximately two revolutions.

(*l*) As soon as the engine is running, switch off the starter magneto, turn off the priming cock, and set the air-intake heat control to the position for admitting warm air.

(*m*) Should the engine fail to start, make further attempts before injecting more fuel.

Electric Turning Gear.—(*a*) Prepare the engine as detailed in sub-paras. (*a*) to (*h*) above.

(*b*) Prime the engine with fuel as detailed in sub-para. (*j*), but do not turn the engine.

(*c*) Press the starter motor switch and keep in the ON position, at the same time vigorously turning the starter magneto unless it is interconnected with the starter unit as previously mentioned. After approximately 3 to 4 seconds, the engine should start, but should it fail to start in 8 to 10 seconds, release the switch and investigate the cause. In no circumstances should the starter motor be run for longer than 10 seconds; if it should be run for this maximum permissible time, allow it to

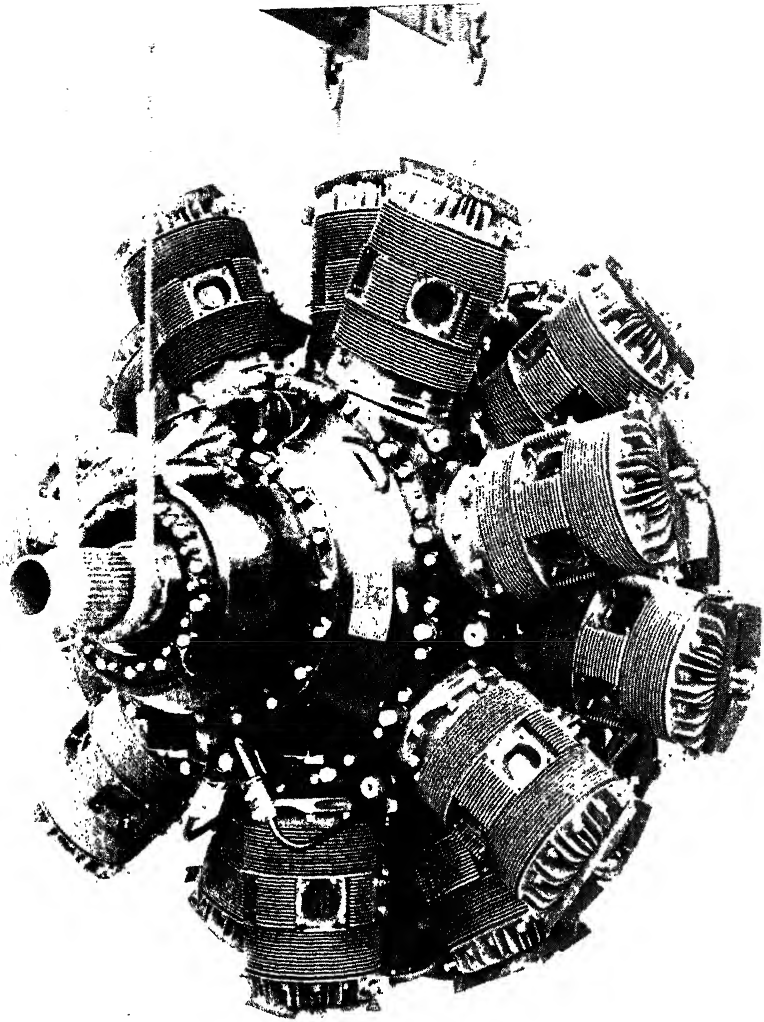

Fig. 4.—"TAURUS" ENGINE

cool off for at least 30 seconds, before making a further attempt at starting.

(*d*) As soon as the engine has started, switch off the starter magneto, turn off the priming cock, and set the air-intake heat control to the warm air position.

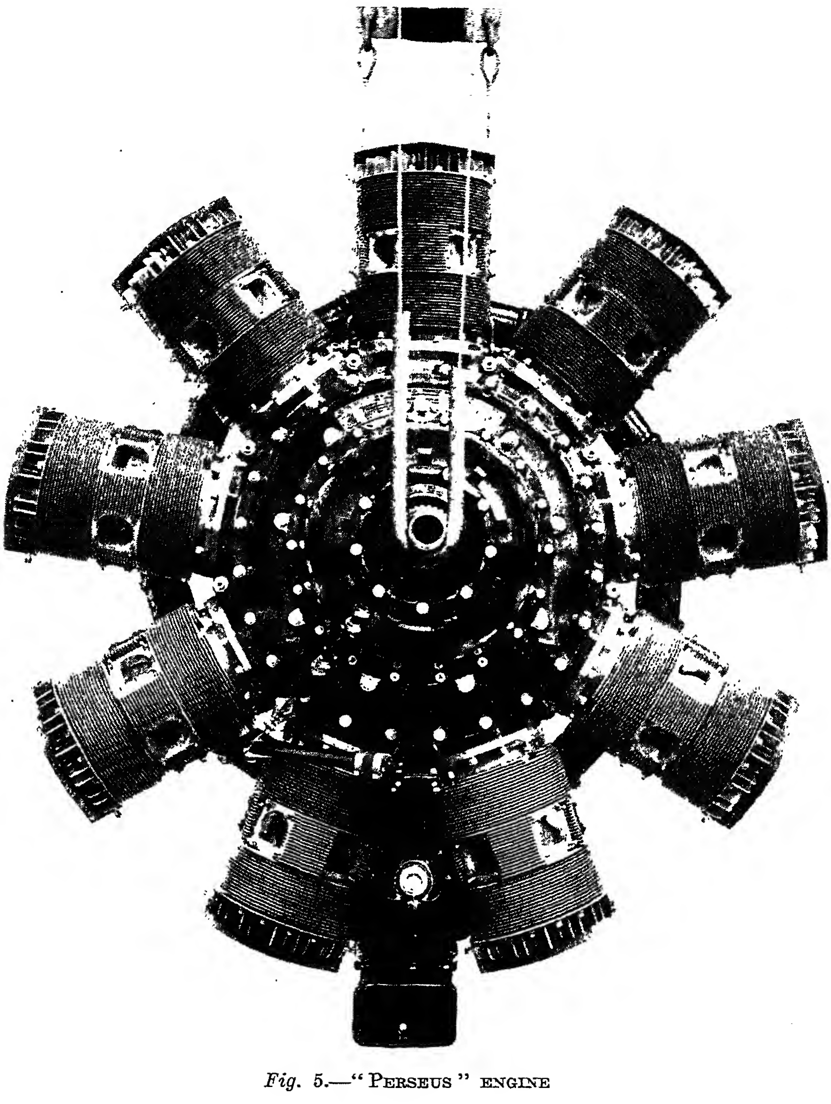

Fig. 5.—"PERSEUS" ENGINE

(2) Hand-operated Inertia Starter

(*a*) Prepare the engine as previously detailed, and inject approximately six to eight pumpfuls of fuel into the induction system by means of the priming pump.

(*b*) Place the crank handle in position, and ensure that the operating rod is in the correct position, i.e. starter jaws disengaged.

(*c*) Turn the starter crank slowly at first without applying any great effort, and as the speed increases, exert a greater force. Continue rotating the handle until it attains a speed of 75 to 80 r.p.m., which should take approximately 30 to 45 seconds.

(*d*) Immediately the requisite speed on the starter handle has been attained, turn the hand-starter magneto vigorously and pull the operating rod to engage the starter jaw with the engine jaw, and hold in engagement until the engine fires.

Note.—In order to minimise delay, it is important, in the case of a hand-operated starter magneto, that the magneto is being turned when the starter jaw engages, as the engine only rotates one and a half to three revolutions.

(*e*) As soon as the engine is running, switch off the starter magneto, turn off the priming cock, and set the air-intake control to the warm air position.

(*f*) If the engine fails to start, push on the operating lever to ensure disengagement of the starter jaws before repeating the foregoing procedure.

Note.—The engine will not start unless the requisite speed has been attained on the cranking handle, as the necessary energy will not be available in the flywheel. As experience is gained, the operator will learn to tell, from the note of the flywheel, when he has obtained the correct speed before operating the clutch throw-in lever. The starter jaws disengage automatically as soon as the engine starts, but care must be taken to ensure that free movement of the operating rod is not restricted when returning to the disengaged position.

(3) Combined Hand or Electrically Operated Inertia Starter

With this unit the energy is imparted to the flywheel either by hand cranking or by an electric motor. When the hand-cranking method is employed, the procedure is identical to that described in para. (2) above.

Electrically Energised Inertia Starter.—(*a*) Prepare and prime the engine as previously described.

(*b*) Push the switch to start the motor and keep it in the ON position for 5 to 6 seconds. This period will normally be sufficient for the flywheel to attain its correct speed.

(*c*) As soon as the required speed is reached, pull the switch control, which will open the electrical circuit and at the same time engage the starter jaw with the jaw on the engine crankshaft.

(*d*) At the same time as the clutch is engaged, turn the starter magneto vigorously.

(*e*) Immediately the engine starts, place the starter magneto switch in the OFF position, turn off the priming cock, and set the air-intake control to the warm-air position.

Note.—The starter motor must not be operated for periods longer than

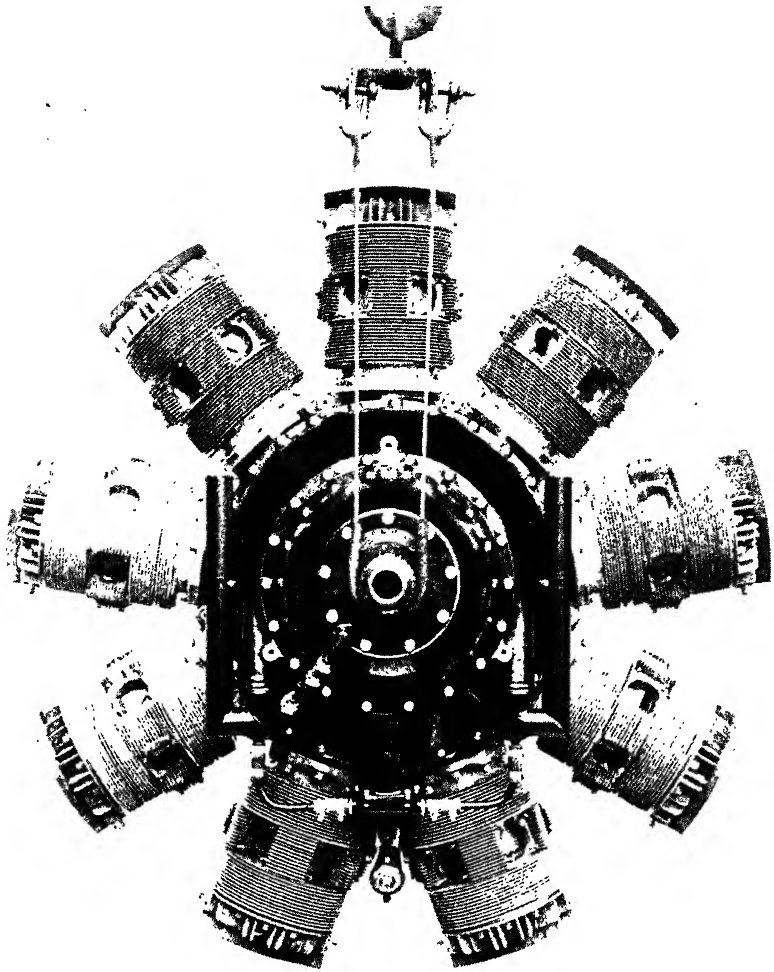

Fig. 6.—"AQUILA" ENGINE

10 seconds, and should the engine fail to start within this time, allow the motor to cool down for at least 30 seconds before making a further attempt.

(4) Coffman Combustion Starter

This starting apparatus consists of two main parts, the breech mechanism for firing the cartridge, and the starter connected to the breech. In a single-engine aircraft the connecting pipe is generally arranged so that

the breech is fixed in the cockpit, where it can be loaded easily. In the case of multi-engine installations, a magazine-breech mechanism holds enough cartridges at one loading to deal with the probable number of starts during the required operating period. In either case, the cartridge is fired on each occasion by an electric current through a switch in the cockpit.

The starter unit itself is mounted in the usual position on the rear cover of the engine ; it has a multi-toothed driving dog, which, in the first stage of the application of the combustion-gas pressure to a piston inside the unit, moves forward into engagement with a corresponding jaw on the tail shaft of the engine. As the gas pressure further increases with the burning of the charge in the cartridge, the continued forward movement of the piston is transformed by an arrangement of helical splines into a turning movement of the driving dog, and therefore of the engine. Suitable safety devices deal with unrequired gas or excessive pressures. This starter is light, and can be operated entirely by the pilot.

For starting the engine the usual preliminary steps are taken, and when ready the push button is pressed.

RUNNING THE ENGINES

The high initial oil-pressure device incorporated in the oil pump of these engines provides a safeguard against oil starvation during the first few minutes of running.

Although with this device in action it is possible to accelerate almost immediately after starting—provided the minimum permissible oil inlet temperature of 5° C. has been reached—it is strongly recommended that, under normal conditions of operation, the engine should not be opened up to full power or the aeroplane taken off until the oil inlet temperature is at least 15° C.

In the case of an engine that has been started up for the first time after installation or a long standby, it is imperative that the full warming-up procedure and ground test be carried out as stipulated below.

Warming-up

(1) Immediately after starting, the engine should be throttled to approximately 600 r.p.m. (800 r.p.m. in the case of the " Perseus " engine) and allowed to run at this speed for about 5 minutes. The oil pressure should build up straightway ; should it fail to do so, discontinue the run and investigate the cause.

(2) Open up from 600 r.p.m. (800 r.p.m. " Perseus ") in steps of 200 r.p.m. every 2 minutes, keeping the speed below 1,000 r.p.m. (1,200 r.p.m. " Perseus ") until the oil pressure settles and the oil-inlet temperature rises to at least 15° C. It should be noted that, while the high initial oil-pressure device is in operation, the oil pressure will vary with the temperature and engine speed, and may rise to 150–200 lb. per square inch

when starting with cold oil. As the oil temperature rises, however, and H.I.O.P. device goes out of action, the pressure will settle at the normal 80 lb. per square inch. If, after settling, the pressure commences to fluctuate or is more than 5 lb. per square inch below normal at 1,200 r.p.m. or over, the oil system should be carefully examined for leaks, which, if found, should be rectified.

The oil relief valve is adjusted and sealed by the manufacturers, and must only be readjusted by authorised persons. In the unlikely event of alterations to the setting being necessary, it is important that the oil temperature be raised to 70° C. before finally sealing the adjustment.

(3) When satisfied that all is functioning normally, set the air-intake control to the cold air position, after which the engine may be opened up to check r.p.m., boost, etc., as detailed below.

ENGINE GROUND TEST ("MERCURY" AND "PEGASUS")

(1) It is important to note that the engine should not be run at full throttle for periods exceeding 10 seconds, as in the majority of installations it is heavily cowled, and does not receive its normal cooling airstream until in flight.

(2) Always open and close the throttle in a smooth progressive manner and without snatching. This is particularly important with a geared engine turning a heavy airscrew, owing to the high inertia of the airscrew.

(3) On installations fitted with controllable cowling gills, it is essential that these be opened fully during all ground running.

Assuming that the engine is working normally, open the throttle fully, and observe the boost pressure whilst running with the mixture control in the "normal" position and with a V.P. airscrew in the fine pitch position, the specified maximum cruising boost should be obtained.

With the same V.P. airscrew pitch setting and mixture control moved to the "rich" or override position, note the boost obtained with the throttle control in the full-open position. In the case of the fully supercharged engines, the maximum r.p.m. obtainable on the ground with either a V.P. or a fixed-pitch airscrew should be sufficient to give the specified take-off boost pressure. With the medium supercharged engines, however, the minimum r.p.m. at which the specified maximum take-off boost is obtainable may not be attained at full throttle on the ground, and the take-off boost will be correspondingly reduced. In these instances the override adjustment should not be altered in an attempt to obtain the maximum boost. The fuel pressure should be checked during this test.

Should there be any discrepancy in the boost pressure, a careful check must be made (*a*) of the attachment of the carburettor to the volute casing ; (*b*) that the aircraft controls are correctly adjusted ; and (*c*) that the boost gauge is reading correctly.

The engine should not be run at rated boost for longer than 10 seconds when checking the engine r.p.m. and switches on the ground, since the engine does not receive its normal cooling airstream until it is in flight. The drop in r.p.m. at rated boost with either magneto switched off should not be more than 120 r.p.m. Do not switch off both magnetos when the engine is running above 800 r.p.m.

The acceleration of the engine should be checked, by opening the throttle steadily after a few minutes running idle. The engine should accelerate from the slow-running or any intermediate throttle setting to the maximum ground r.p.m. without any signs of a " flat spot " or cutting out due to a weak mixture.

In order to check the operation of the V.P. airscrew control, the engine should be throttled back to approximately 1,500 r.p.m. in fine pitch, and the control changed to coarse pitch (cruising) setting. This should make the r.p.m. decrease slightly if the pitch-operating mechanism is working correctly.

After the preliminary run, stop the engine and examine for fuel or oil leaks. Check the V.P. airscrew or airscrew hub for tightness on shaft, finally lock hub nut. All external nuts should be checked and retightened if necessary.

The oil filter in the sump should be examined for signs of foreign matter, and should any traces be found, the system must be drained and the tanks cleaned. The running test and cleaning operations must be repeated until the system is clear.

Should the filter show traces of any metallic particles, the origin of these should be ascertained.

Slow Running.—The throttle stop on the carburettor is set by the makers when the engine is on the test bed, and should not normally require alteration. Owing, however, to possible variations in the characteristics of different airscrews and slight differences in the grade of fuel used, a minor adjustment may sometimes be found desirable. First run the engine until it is thoroughly warmed up, then release the throttle stop-lock nut and screw the stop slowly in or out, as required, until the desired slow-running speed (approximately 500 r.p.m.) has been obtained, after which tighten the locknut securely. Before undertaking this adjustment, it is important to ensure that the throttle-spindle lever is actually in contact with the throttle stop, and this may be checked by means of a 0·002-in. feeler gauge.

Vibration.—There should be no undue vibration throughout the entire speed range of the engine, but should any be experienced, the following possible causes should be considered :

(*a*) *Airscrew out of Balance.*—Rough running due to this cause may generally be recognised by a characteristic rhythmic beat, increasing in frequency with increasing r.p.m. Check the track of the airscrew blades, and ensure that the airscrew is tight on its hub and the hub tight on the

shaft. If no improvement, remove the airscrew and check for static balance.

(b) *Unevenly Set Valve Clearances.*—Reset to the standard clearances.

(c) *Sparking Plugs Dirty or Badly Gapped.*—Clean, readjust the gaps, and test under pressure on a rig.

(d) *Slackened Bracing or Worn Pins in the Fuselage Structure in the Rear of the Engine Bay.*—The point of occurrence of vibration may be detected by placing a finger on the suspected fitting while the engine is idling, when relative movement between the two surfaces should be readily apparent. Apply the appropriate remedy.

Shutting Down

These engines are provided with carburettor slow-running cut-out valves, which are controlled from the cockpit. When shutting down, close the throttle, switch off the magnetos, and operate the control to pull out the cut-out valves. It is important to follow this sequence of operations, as, were the pilot to release the control accidentally, with the magnetos still switched on, the engine would probably pick up again. Immediately the engine has stopped, the control should be returned to the normal open position.

After Stopping the Engine

After stopping the engine following a first run, examine for fuel or oil leaks, and check over all external nuts ; re-tighten, if necessary. Remove the oil filter in the sump, and examine for signs of foreign matter ; if trace of this be found, drain the system and wash out the tanks, repeat running and cleaning operations until the system is clear. In the event of bronze, white metal, or other metallic particles being found in the filter, the origin should be located before further running is carried out.

Check the airscrew hub or variable-pitch airscrew for tightness on the shaft as previously described, finally making sure that the airscrew locking devices are in position and secure.

Take-off, Climb, and in Flight

If, after the engine has been ground tested, there is any delay before the aircraft is taken off, it is most important that the engine be given a burst of power at intervals of not longer than 5 minutes ; run engine up to zero boost and check switches.

With the airscrew control in the fine pitch position for take-off and the cowling gills fully open, the pilot must spring the mixture control lever in the cockpit through the gate to the rich mixture position to bring the overriding device and enriching device into action. The throttle control in the cockpit must then be moved to the full open position when maximum ground boost will be obtained.

Whilst climbing, the controls may be left in the take-off position until

the aircraft has climbed to approximately 1,000 ft., when the mixture control must be returned to the normal position and the climb continued at a boost not exceeding the specified climbing maximum with V.P. air-screw control in the coarse pitch position. Care must be taken that the maximum permissible take-off r.p.m. are not exceeded.

If, after take-off, the aircraft is to be cruised at low altitudes of approximately 1,000 ft. or less, the mixture controls must be returned to normal and the airscrew controls set at coarse pitch position within 2 minutes of unsticking.

In flight the controls are operated in the normal manner. The automatic boost control regulates the maximum throttle opening, ensuring that the rated boost is not exceeded, and thus relieving the pilot of the necessity for watching the boost gauge.

Oil Pressure.—Terminate the flight if the oil pressure falls below the dangerous minimum specified.

Oil Temperature.—In flight the inlet oil temperature should not exceed 70° C. for cruising, but for short periods during a climb, a maximum inlet temperature of 80° C. is permissible.

Cylinder Temperatures

Take-off and climb	Maximum 235° C.
All-out level	Maximum 235° C. (5 mins. limit)
Cruising	Maximum 190° C.
Economy cruising	Maximum 180° C.

R.P.M.—*In Level Flight,* maximum cruising r.p.m. must not be exceeded for periods longer than 5 minutes.

Cruising Conditions.—Under conditions of normal cruising, as for instance when undertaking an ordinary cross-country flight as distinct from exercises or emergency conditions, it is recommended that the engine be operated at a boost pressure lower than the respective maxima specified for cruising. This recommendation is made solely from the point of view of economical operation with particular regard to the length of periods between overhauls, routine maintenance, life of sparking plugs, etc.

Cruising at Normal Mixture Setting.—Close cowling gills, and with V.P. air-screws in the coarse pitch position, proceed as follows :

(1) Adjust throttles to give desired cruising r.p.m.

(2) Advance mixture controls gradually towards the weak position until the r.p.m. just cease to increase.

(3) Gradually throttle back to original r.p.m.

Cruising at Economy Setting.—When the most economical fuel consumption is required, it is permissible to utilise extra mixture control until a 3 per cent. drop in r.p.m. is obtained, provided the specified maximum permissible boost under economy cruising conditions and 2,250 r.p.m. (2,400 r.p.m. for the "Mercury" engine) are not exceeded. Proceed as follows, in order to obtain the correct setting of the mixture controls :

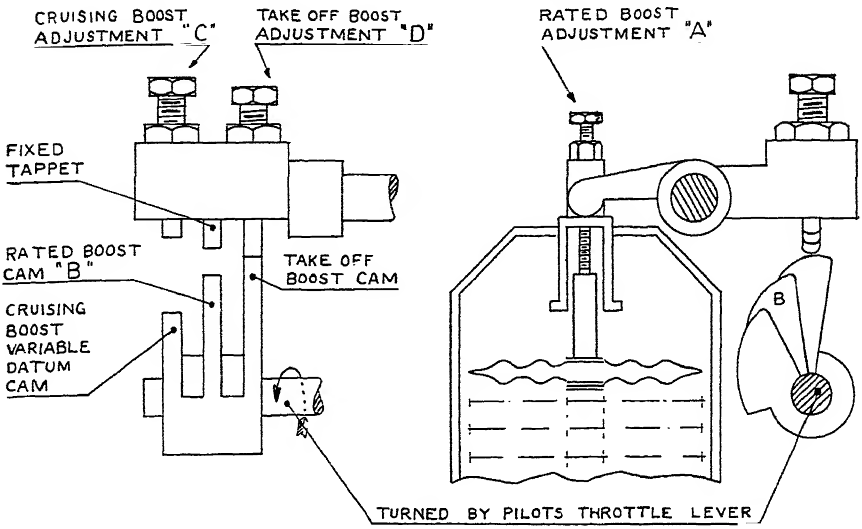

Fig. 7.—THREE-STAGE AUTOMATIC BOOST CONTROL

(1) With the aeroplane flying level at the correct cruising r.p.m. and the airscrew in coarse pitch position, set the mixture controls as for cruising at normal mixture conditions.

(2) Move the mixture controls farther towards weak position until a drop of 3 per cent. in r.p.m. is obtained.

(3) Gradually open throttles to regain the original r.p.m. It is important that the aircraft is flown in steady and level flight throughout this procedure.

If, during the course of the flight, the altitude is changed appreciably, that is, by more than 1,000 ft., the mixture control must be returned to normal and the above procedure repeated.

Use of Carburettor Heating (Air Intake).—The various conditions under which the air intake shutter control should be operated are as follows, and it is essential that these instructions be adhered to for satisfactory operation :

Warm Air.	*Cold Air.*
Low air temperature.	Starting.
Gliding.	Full power.
Damp atmosphere.	Fine weather conditions.
Rain.	
Clouds.	
Snow.	

Use of Controllable Cowling Gills (if fitted).—The following may be taken as a general guide for the setting of the cowl gills :

Ground running, taxying . .	Open.
Take-off and climb . . .	Part-open.
Cruising	Closed.

Experience with the aircraft concerned in conjunction with cylinder temperature recording apparatus will enable the pilot to obtain finer control when climbing, but no definite rule can be laid down as to the exact degree of gill opening, as it depends entirely on the speed and power developed ; the gills should be closed as far as possible without causing the specified maximum cylinder temperature to be exceeded.

Use of V.P. Airscrew Pitch Control.—At fine pitch setting the airscrew develops high thrust at low air speeds for taxying, take-off, initial climb, and for landing.

At coarse pitch setting, maximum efficiency at altitude and high airspeeds is obtained, that is, for climbing above 1,000 ft., and for all level flight conditions.

The use of fine pitch in level flight will contribute to over-revving and adversely affect fuel economy. If, however, the aircraft is being flown slowly under conditions of very bad visibility, it is desirable to change the airscrew to the fine pitch position to keep the engine running at reasonable r.p.m. It is of the utmost importance, however, to return the airscrew to coarse pitch as soon as the aircraft has cleared the area of bad visibility and is able to fly at normal cruising airspeeds.

Landing.—When coming in to land, the airscrew should be moved to the fine pitch setting to ensure that it is in the correct position for an emergency.

ENGINE GROUND TEST (" PERSEUS ")

When the engine is running normally, and the required minimum oil temperature of 15° has been obtained, tests should be made to check boost, r.p.m., and airscrew control.

Rated Boost and R.P.M.

Set the two-pitch airscrew, if one is fitted, in the fine pitch position ; if a constant speed airscrew is fitted the governor control should be set to r.p.m. not exceeding 2,250. With the mixture control lever in the " normal " position and the throttle lever moved to the " rated " position, a boost pressure of + 1¼ lb./sq. in. should be obtained.

Take-off Boost and R.P.M.

Set the two-pitch airscrew in the fine pitch position and if a constant speed airscrew is fitted, set the governor control to " take-off " r.p.m. (2,700). With the mixture-control lever in the " normal " position and the throttle lever in the "take-off" position,a boostpressure of + 3 lb./sq.

in. should be obtained. Under these conditions, with a two-position V.P. airscrew, the drop in r.p.m. with each magneto earthed in turn should not exceed 120. With a constant speed airscrew, however, the r.p.m. drop is to be checked as subsequently described.

Cruising Boost

If a two-pitch airscrew is fitted, it should remain in fine pitch, and if a constant-speed airscrew is fitted, the governor control should be set at r.p.m. not exceeding 2,200. Then with the mixture control lever set in the "normal" position, move the throttle lever to the "cruising" position, when — 1 lb./sq. in. boost should be obtained.

Should there be any discrepancy in the boost pressure, a careful check must be made :

(*a*) Of the attachment of the carburettor to the volute casing.

(*b*) That the aircraft controls are correctly adjusted ; and

(*c*) That the boost gauge is reading correctly and boost pipes are not leaking.

The automatic boost control is set on the test bed and afterwards locked, and no further adjustment should be necessary except in the event of replacement parts having been fitted. Should any alterations to the setting be required, the procedure is as follows :

(i) With the mixture control in automatic rich and the airscrew governor control set to give 2,250 r.p.m., open the throttle momentarily to the "R.B." position (marked on the quadrant plate situated on the carburettor) and note the amount of error in the boost value. Shut down engine and adjust the rated boost to the required value (+ $1\frac{1}{4}$ lb./sq. in.) by means of the adjuster "A" (see Fig. 7) on the boost control. One complete turn of the adjuster gives approximtely 1 lb./sq. in. alteration in the boost value. Repeat the above procedure until the desired climbing boost pressure is obtained.

(ii) With the throttle in the "C.B." position, the mixture control lever in the "normal" position and the airscrew governor control set to allow the engine to run at cruising r.p.m. (2,200), adjust the boost pressure, in a manner similar to that described in the foregoing paragraph, to the maximum boost allowable for weak mixture (— 1 lb./sq. in.) by means of adjustable tappet "C," which is turned clockwise to increase the boost pressure.

(iii) Following the same procedure, adjust the take-off boost pressure (+ 3 lb./sq. in.) by means of adjustable tappet "D," the throttle being set in the "T.O.B." position, the airscrew governor control set to give approximately take-off r.p.m. (2,700), and the mixture control in the "normal" position.

During the above procedure, a two-pitch airscrew, if one is fitted, should be in the fine pitch position.

After each adjustment is carried out, and before opening up the engine

for checking purposes, it is most important that the carburettor linkage cover is replaced, in order to prevent dust and grit entering the carburettor from the airscrew slip stream.

In the event of any adjustments being made to the boost control, the fact that the settings have been disturbed and the reason for so doing must be recorded in the engine log book.

Do not run at rated boost for longer than 10 to 20 seconds when checking the engine r.p.m. and switches on the ground, as the engine does not receive its normal cooling airstream until it is in flight. During all ground testing, it is important to note that the engine must not be run unless the cylinder baffles and the engine cowlings are fitted and the controllable gill cowlings must be set in the fully open position. Check for satisfactory acceleration.

Checking Airscrew Control (Constant Speed Type)

To check the functioning of a constant-speed airscrew, run the engine with the throttle lever in " C.B." gate position (— 1 lb./sq. in.), and move the airscrew governor control lever to the position giving maximum r.p.m. Note the r.p.m. obtained, and move the governor control lever slowly back into the positive coarse pitch position ; this action should cause an appreciable drop in r.p.m. Return the lever to the maximum r.p.m. position, and note that the original r.p.m. are restored.

With the airscrew governor set to give any engine speed obtainable at ground level within the governor range, open and close the throttle slightly ; the engine r.p.m. should remain constant. Sudden opening of the throttle will cause a momentary increase in r.p.m. which, however, should settle back to the controlled value and there remain steady.

At this stage, when a constant-speed airscrew is fitted, it will be convenient to check the magneto drop. Open the throttle lever to the " rated " position, and adjust the airscrew governor control lever to give 2,250 r.p.m. Close the throttle lever until 2,200 r.p.m. are registered, thus ensuring that the airscrew blades are against their fine pitch stops. Note the drop in r.p.m. with each magneto switched off in turn ; this should not exceed 110.

Checking Airscrew Control (Two-pitch Type)

To check the functioning of the two-pitch airscrew control when fitted, the engine should be run at approximately 1,800 r.p.m. in fine pitch. Change to coarse pitch (cruising) setting. This action should cause the r.p.m. to decrease appreciably if the pitch-operating mechanism is working correctly.

Before stopping the engine, see that the airscrew blades are in the coarse pitch position, as this will enable the ground engineer to carry out adjustments and routine inspection more easily.

After the preliminary run, stop the engine by closing the throttle,

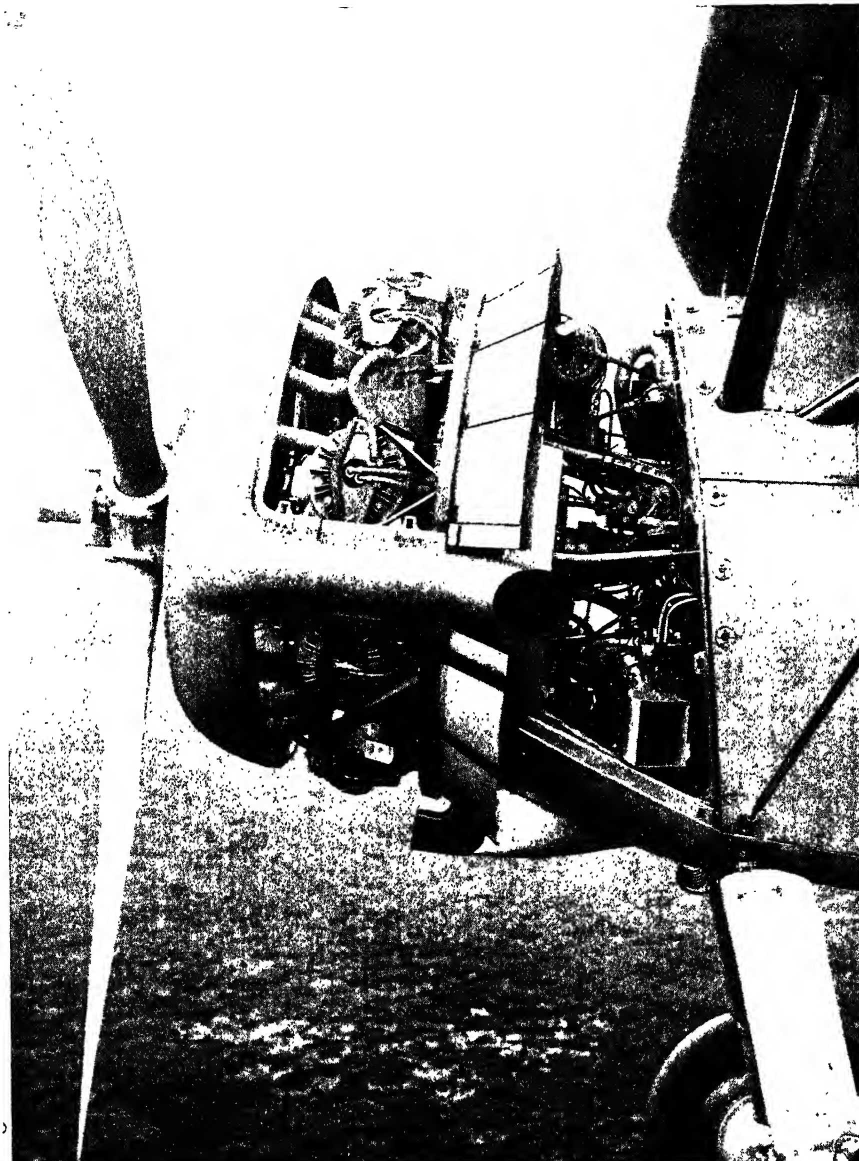

Fig. 8.—INSTALLATION OF "PERSEUS" ENGINE FITTED WITH DE HAVILLAND V.P. AIRSCREW

The ring cowl has been removed to show the inter cylinder baffles, and the controllable gills are shown in the open position.

switching off the ignition and operating the carburettor cut-out control. Do not operate cut-out control before switching off.

(i) Examine for fuel or oil leaks.

(ii) Check the tightness of the airscrew on the shaft. Check over all external nuts and retighten if necessary.

(iii) Remove and examine the oil filter in the sump for signs of foreign matter ; if trace of this be found, drain system and wash out tanks—repeat running and cleaning operations until the system is clear.

In the event of bronze, white metal, or other metallic particles being found in the filter, the origin should be located before a further running is carried out.

Take-off, Climb, and in Flight

Start the engine.

For continued taxying, do not exceed 1,500 r.p.m., so that overheating the engine before taking off is avoided.

If there is any delay before taking off and the engine has been allowed to idle for a prolonged period, it should be given a burst of power at intervals of not longer than 5 minutes.

With a two-pitch airscrew control in the fine pitch position, or, in the case of a constant-speed airscrew, with the governor control adjusted to give maximum r.p.m., the pilot must move the throttle lever in the cockpit to the full open position. This movement of the throttle also provides automatically the necessary increase in mixture strength.

The controls may be left in the take-off position until the aircraft has climbed to approximately 1,000 ft., or for not longer than 2 minutes from unsticking (whichever is the shorter time).

Continued Climb (above 1,000 ft.)

The throttles must be closed to the rated boost ($+ 1\frac{1}{4}$ lb./sq. in.) position and the constant-speed airscrew governor adjusted to give 2,250 r.p.m., or if a two-pitch airscrew is fitted, the control set to the coarse pitch position, when the climb may be continued to the desired altitude.

Cruising Conditions

On reaching cruising altitude, it is desirable, particularly with a newly installed engine, to check the functioning of the mixture control as follows :

With the mixture-control lever in the " normal " position, move the throttle lever to a position in the economy cruising range, where the maximum economic cruising boost and maximum economic cruising r.p.m. are not exceeded. Move the constant-speed airscrew governor control lever to " positive " coarse pitch position to " lock " the airscrew blades ; when the r.p.m. have settled in level flight, move the mixture control lever to " weak," the throttle lever being left untouched. This

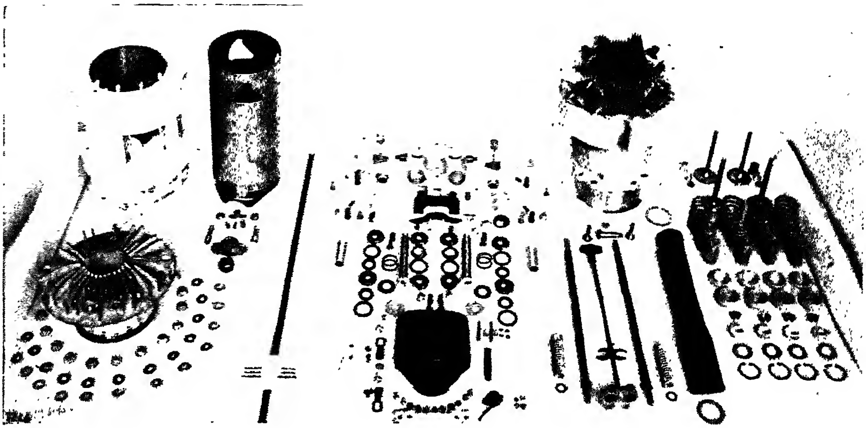

Fig. 9.—COMPARISON OF POPPET VALVE AND SLEEVE VALVE CYLINDER ASSEMBLIES

weakening will cause a drop in r.p.m., which should be approximately 3 per cent. of the r.p.m. in normal mixture, if the mixture control is working correctly. With a two-pitch airscrew, the test may be carried out in coarse pitch.

Cruising at Automatic Weak (Economy) Setting

The throttle lever should not be moved beyond the " cruising " position, with the mixture control lever in the " weak " position and the two-pitch airscrew (if fitted) in the coarse pitch position. If a constant-speed airscrew is fitted, the governor control should be set to the desired r.p.m. not exceeding 2,200. The following flight conditions for economy and normal cruising should not be exceeded :

Height	*Weak Mixture Cruising Boost*	*Normal Mixture Cruising Boost*
Sea level	— 1 lb./sq. in.	— 1½ lb./sq. in.
3,000 ft.	— 1 lb./sq. in.	— 1½ lb./sq. in.
5,000 ft.	— 1¼ lb./sq. in.	— 1¾ lb./sq. in.
7,000 ft.	— 1½ lb./sq. in.	— 2 lb./sq. in.
10,000 ft.	— 1¾ lb./sq. in.	— 2¼ lb./sq. in.

The mixture-control lever can only remain in the " weak " position while the throttle lever is in the weak mixture cruising range, and movement of the throttle beyond this point or back to the slow-running position automatically returns the mixture-control lever to " normal." The mixture-control lever may, however, be left in the " normal " position throughout the range of the throttle-lever movement. This is desirable for manœuvring at small throttle openings on the ground.

Some extra effort may be necessary to move the throttle lever when the mixture control lever is set at " weak."

Cruising at Automatic Rich Mixture Setting

For cruising in normal mixture, a two-pitch airscrew should be in the coarse pitch position, and when a constant-speed airscrew is fitted, the governor control adjusted to r.p.m. not exceeding 2,200, and boosts should not exceed those quoted under " normal mixture cruising boost " at the specified heights. Above 10,000 ft. the throttle lever can be in the " cruising " position with either " normal " or " weak " mixture. Although it is permissible, when cruising in normal mixture, to employ $+ 1\frac{1}{4}$ lb./sq. in. boost with the constant-speed airscrew governor control adjusted to give 2,250 r.p.m., this boost pressure and r.p.m. may only be used in an emergency for a short period.

Use of Constant-speed Airscrew

In the unlikely event of a failure in the airscrew oil line when a constant-speed airscrew is fitted, the governor control should be moved into the position giving fully or " positive " coarse pitch. This will shut off the flow of oil to the airscrew, and thus prevent loss of oil from the engine main supply system. This action will cause the airscrew to become virtually " fixed pitch," and the engine r.p.m. will then become controllable directly by the throttle.

In a glide, the constant-speed airscrew pitch control cylinder moves to the fully " fine pitch " position, and becomes filled with oil, which, if the air temperature is very cold, will tend to congeal and lock the airscrew in fine pitch. It is recommended therefore that before throttling back to glide in very cold atmosphere, the airscrew governor control should be moved to the positive coarse pitch setting while the engine is running at not more than " C.B." throttle setting (i.e. — 1 lb./sq. in. boost). This will ensure that the oil is expelled from the pitch control cylinder while it is warm and free to flow. On reaching the desired lower altitude or before approaching to " land," the constant-speed control should be moved to the desired r.p.m. setting and the throttle opened up.

Adjustment of Constant-speed Airscrew and Governor Control

The airscrew blade fine pitch stops should be set so that 2,700 r.p.m. are obtainable with the governor control set for take-off r.p.m. If, however, the basic pitch setting of the airscrew to satisfy high-speed requirements in flight is very coarse, then with the fine pitch blade stops at their fine limit, i.e. giving fully 20° pitch range, the maximum static r.p.m. will be less than 2,700 and must be accepted. With the blade stops so adjusted and with the governor control set for take-off r.p.m., the airscrew will tend to over-rev. during take-off because the governor may be attempting to govern at, say, 2,800 r.p.m.

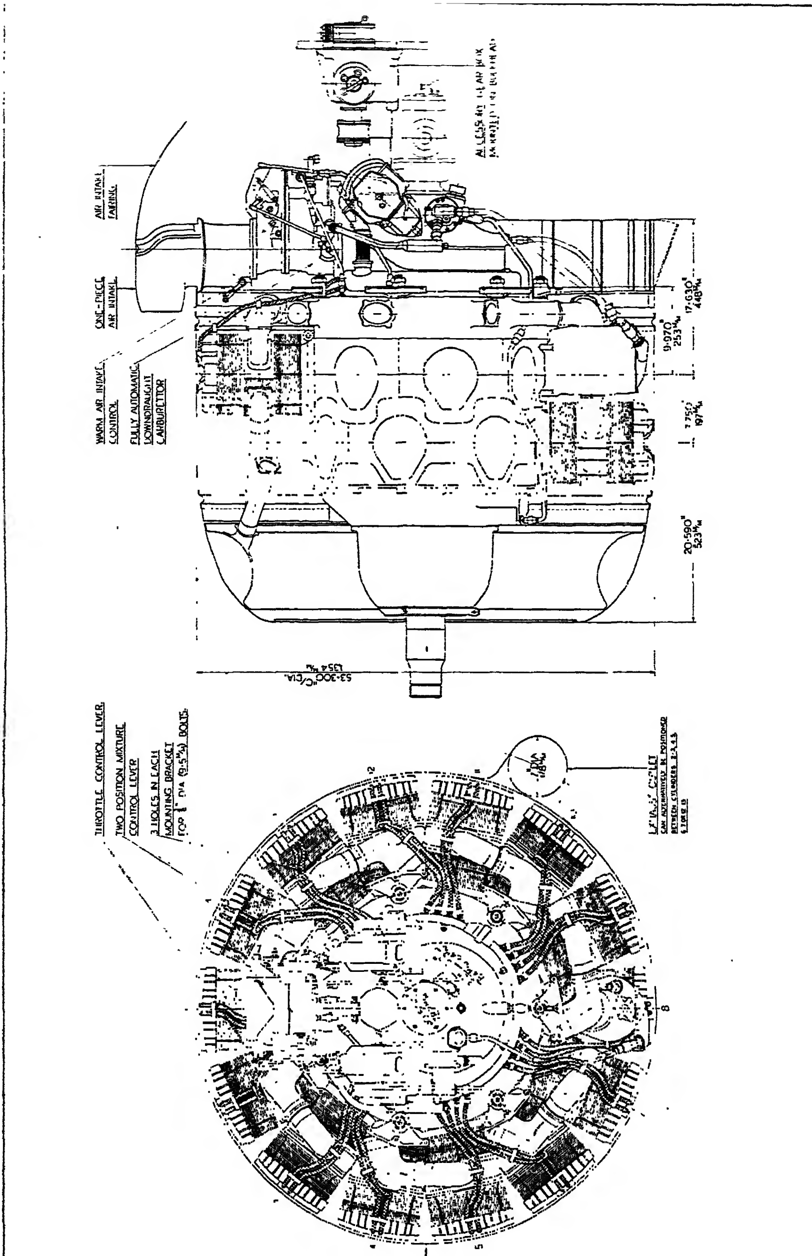

Fig. 10.—"HERCULES" ENGINE INSTALLATION DIAGRAM SHOWING ACCESSORY GEAR BOX

Therefore, the over-revving should be overcome by pulling back the governor control, and its position for 2,700 r.p.m. in flight at any reasonable throttle setting for slow cruising should be marked and " gated " as the subsequent correct take-off position which will not allow 2,700 r.p.m. to be exceeded under any condition.

Use of Two-pitch Airscrew and Constant-speed Airscrew Cockpit Controls

For taxying, take-off, initial climb, and for landing, the airscrew control should be in the fine pitch position, at which the airscrew develops high thrust at low air speeds. When a constant-speed airscrew is fitted, the cockpit control should be set at the position corresponding to take-off r.p.m. To obtain maximum efficiency at altitude and high air speeds, that is for climbing above 1,000 ft. and for all level flying conditions, the coarse pitch setting should be used, or, in the case of a constant-speed airscrew, the r.p.m. should be determined by the position of the cockpit control. The fine pitch setting should not be used in level flight, as this will contribute to over-revving and will adversely affect fuel economy. If, however, the aircraft is being flown slowly under conditions of very bad visibility, it is desirable to change the airscrew to the fine pitch position to keep the engine running at a reasonable r.p.m., which should be done by changing a two-pitch airscrew to the fine pitch position, and by the use of the governor control in the case of a constant-speed airscrew. With a two-pitch airscrew, it is of the utmost importance, however, to return airscrew to coarse pitch as soon as the aircraft has cleared the area of bad visibility, and is able to fly at normal cruising airspeeds.

When coming in to land with a two-pitch airscrew, the airscrew should be moved to the fine pitch setting to ensure that it is in the correct position for an emergency. With a constant-speed airscrew the control should be set to the position corresponding to climbing r.p.m.

Air Intake Shutter Control Setting

The various conditions under which the shutter control should be operated are as follows, and it is essential that these instructions be adhered to for satisfactory operation :

Warm Air.	*Cold Air.*
Low air temperature.	Starting.
Gliding.	Full power.
Damp atmosphere.	Fine weather conditions.
Rain.	
Clouds.	
Snow.	

Use of Controllable Cowling Gills

For ground running and taxying, the gills must be in the fully open position, while for take-off and climb a partly open setting (not more than

half open) will be found the most suitable; for cruising under normal conditions, they should be closed. The cylinder temperatures registered should not exceed those quoted in the leading particulars, and the cowling gills should be set accordingly to suit the conditions.

If the specified temperatures are exceeded, abnormal conditions are indicated, and if the adjustments possible in flight do not bring temperatures back to normal, the engine concerned should be throttled back, the mixture control set at "normal," and on landing, the matter should be reported and the engine examined.

On the first flight, or with new installations, observe the following:

(i) *Oil Pressure.*—Terminate the flight if the oil pressure falls below minimum specified, i.e. 70 lb./sq. in. at r.p.m. above 1,500.

(ii) *Oil Temperature.*—In flight the inlet oil temperature should not exceed 70° C. for cruising, but for short periods during a climb, or in an emergency, a maximum inlet temperature of 80° C. is permissible.

(iii) *R.P.M.*—In level flight, normal r.p.m. must not be exceeded for longer than five-minute periods.

(iv) *Vibration.*—No undue vibration should be experienced throughout the speed range of the engine.

Stopping the Engine

To facilitate the carrying out of routine inspection and adjustments, move the two-pitch airscrew, if fitted, to the coarse pitch position before shutting down the engine. If a constant-speed airscrew is fitted, move the governor control lever to the "positive" coarse pitch position.

In the carburettor a slow-running cut-out device is fitted which is controlled from the cockpit, therefore, when shutting down, it is necessary to throttle back, then switch off and operate the cut-out device. It is important to follow this sequence of operations to avert the possibility of the engine picking up again in the event of the pilot accidentally releasing the valve.

MAINTENANCE OF POPPET-VALVE AND SLEEVE-VALVE ENGINES

It is interesting to note the difference in the poppet-valve and sleeve-valve cylinder assemblies shown in Fig. 9, from which it will be seen that the sleeve valve has less parts to be maintained.

Routine Maintenance

It is most important that regular and proper maintenance is carried out in accordance with the schedules laid down in order that efficient and trouble-free running may result.

The periods given in the following notes are based on experience, and are a good guide, but in cases where engines are operating under severe conditions, it may be necessary to carry out inspections at shorter periods.

There is a variety of accessories, including air compressors, electric starters, generators, etc., which are proprietary articles, and the maintenance instructions regarding these and issued by the manufacturers should be noted.

After each Day's Flight

(1) Examine the pilot's report, and in the event of there being any remarks regarding abnormal engine running, carry out the necessary adjustment forthwith.

(2) See that the ignition switches are in the OFF position.

(3) Generally examine the fuel and oil systems for obvious leaks. See that all unions are properly locked, and that the flexible joints are intact and in good condition. Inspect all fuel-pump plugs, etc., for security and fuel tightness.

(4) Clean out the fuel filters.

(5) Replenish the fuel and oil tanks if necessary, and see that the filler caps are properly secured.

(6) Inspect all engine controls and see that locking devices are intact.

(7) Check tightness and locking of all main nuts and bolts.

(8) Carry out a careful visual examination of the valve gear ; see that all valve springs are intact, and that the hardened buttons pressed into the end of the valve stems are secure. If excessive wear of stem buttons is found, examine the corresponding adjusting screw-thrust button for sticking, as this is the most likely cause of the trouble developing ; both should be replaced if wear is apparent. (Applies only to "Mercury" and "Pegasus.")

(9) Examine all H.T. leads, and see that the sparking-plug connections are secure.

(10) Test the throttle and mixture controls, also the air intake shutter and slow running cut-out controls for freedom of movement.

After each Ten Hours' Running (in addition to daily adjustments)

(1) Remove the filter in oil sump and examine for metallic particles ; clean and replace. The presence of metallic particles in suspension with the oil, indicates some abnormal condition, and the cause should be investigated immediately.

(2) Check over the exhaust system, pipe joints, and fastenings, and ensure that the required amount of freedom is present in the exhaust pipe joints.

(3) *Lubricate the V.P. airscrew blades (if fitted) through the nipples provided*, using approved grease. Clean and lubricate the exposed portion of the piston, using the same grease. This should be done with the blades in the coarse pitch position. Remove the counterweight bearing cap, and smear bearings with same grease. Examine the hub for any signs of oil leaks past the leather washer.

(4) Check by hand the clearances of all valves, and if considered excessive, reset. (Applies only to "Mercury" and "Pegasus.")

After each Twenty Hours' Running (in addition to daily and 10-hour adjustments)

(1) Examine rocker adjusting screw-thrust buttons for excessive wear. (Applies only to "Mercury" and "Pegasus.")

(2) Remove rocker bracket covers, and inspect the tie-rod bolts and rocker fulcrum for signs of slackness. Replace bolts, if necessary. Also examine the push-rod upper ends. ("Mercury" and "Pegasus" only.)

(3) Remove, clean, and reset the gaps on all sparking plugs; when replacing, fit new rolled copper-type washers where necessary; smear the threads lightly with a mixture of graphite and grease.

(4) Lubricate the rocker adjusting screws with approved grease. ("Mercury" and "Pegasus" only.)

(5) Check the compression on each cylinder. To carry out this check, remove one sparking plug from each cylinder except the cylinder being tested. On completion of test, remove one plug and fit into the next cylinder to be checked, and so on until each cylinder has been tried in turn. In the event of a cylinder being found with weak compression, it should be removed and the cause located.

(6) Examine magneto contact breakers, check points for condition and gap, and rocker arms for freedom.

(7) Disconnect the fuel pipes at the carburettor and flush out the system. Reconnect pipes and wire lock where necessary.

After each Forty Hours' Running (in addition to daily, 10-, and 20-hour adjustments)

(1) Drain the oil from the tank, pump system, and sump. This should be done whilst the oil is hot to ensure complete draining. Flush out the oil tank with flushing oil or paraffin. In the event of paraffin being used a final flushing should be carried out with clean petrol. Do not, in any circumstances, allow petrol or paraffin to enter the engine lubrication system, and make sure that the tank and oil system are clear of petrol and paraffin before refilling with new oil.

(2) Examine oil cleaner for metallic particles and general cleanliness.

(3) Drain and clean the oil cooler in a similar manner to that described above for the tanks.

(4) Lubricate the magnetos in accordance with the instruction given on the magnetos.

(5) Examine and clean magneto distributor.

(6) Remove carburettor float chamber base plugs, and clean chambers; examine for water deposit.

(7) Lubricate the felt pads in the valve-spring upper washers, using engine oil D.T.D. 109. (Applies only to "Mercury" and "Pegasus.")

(8) Inspect and calibrate boost gauge in accordance with the standard instructions regarding the maintenance of this instrument. It is most important that this instruction is adhered to at the periods stated.

(9) Lubricate single-type fuel pump bearings. Check the union nuts and locking devices, also the relief valve cap for security on both single- and dual-type pumps.

(10) Inspect the variable-pitch airscrew for tightness on airscrew shaft, using spanner provided. Relock after retightening in the approved manner. If a wooden airscrew is fitted, remove airscrew and hub. Examine the split taper collet, also the splines in the hub or on the airscrew shaft. Tighten the hub bolts and re-split pin. After reassembly ensure that the hub is tight on the shaft and that all locking devices are secure.

After 120 Hours' Running (in addition to daily, 10-, 20-, and 40-hour adjustments)

(1) Charge the rockers with approved grease until discharging around the bearings, using grease gun provided. Wipe away surplus lubricant. (Applies only to "Mercury" and "Pegasus.")

(2) Remove the rocker covers carrying the inlet felt pads, also remove the exhaust felt pad from the bottom of each rocker bracket and submerge in a bath of engine oil (D.T.D. 109) at 50° C. for a minimum period of one hour. After soaking, remove from bath and drain off all surplus oil. Refit the pad to the bottom of the rocker bracket and replace the rocker-bracket cover. Care should be taken to segregate each pad to its respective cylinder, since on initial assembly each is fitted to give a specific lift. When fitting new inlet and/or exhaust felt pads, careful check must be made to ensure that the total lift of each pad is within the limits of 0·100 in. to 0·200 in. (Applies only to "Mercury" and "Pegasus.")

Note.—In no circumstances should the pads be washed, and only when replacement becomes necessary should the inlet pad be removed from the rocker bracket cover.

(3) Remove the felt pads from the valve-spring upper washers, and soak them in engine oil in a similar manner to that detailed above for the rocker pads. (Applies only to "Mercury" and "Pegasus.")

(4) Replace the Tecalemit oil-filter element.

Weekly Maintenance

Every week the engine should be thoroughly inspected, all nuts tightened, locking devices replaced where necessary, particular attention being paid to the following:

(1) Carefully examine all fuel and oil connections, particularly those on the suction side of the fuel and oil pumps.

(2) Examine all controls, see that they are properly locked and pins unworn.

(3) Lubricate the control-rod fork-ends and bulkhead slides.

(4) Examine engine-mounting securing nuts and bolts, particular attention being paid to flexible mounting units when fitted.

(5) In the case of engines fitted with 14-mm. sparking plugs, both the sparking plug and adapter should be inspected for tightness.

Overhaul Periods

The length of periods between overhauls is dependent on the operating conditions. The engine manufacturers will be pleased to give operators their recommendations in this connection on receipt of full details of their operating and climatic conditions, such as revolutions per minute, altitude and boost pressure employed for cruising. Particulars should also be given of the fuel and oil used, also the cylinder temperatures reached on climb and under cruising conditions.

Sleeve-valve Installation uses Accessory Gearbox

An interesting installation feature of the sleeve-valve engines is the arrangement of the engine-driven accessories, and only those which serve the engine are mounted on the rear cover, viz., dual fuel pump, engine oil pump, magnetos, and the constant-speed airscrew governor unit. All the other accessories serving the aeroplane are fitted to a separate accessory gearbox mounted on the bulkhead and driven by the engine through a flexibly jointed shaft. This gearbox is furnished with alternate drives, so that a variety of aeroplane accessories may be fitted as required.

Installation problems are simplified by the adoption of the accessory gearbox, and it is a useful step towards the standardised power unit. A typical installation showing the accessory gearbox fitted to a " Hercules " engine is shown in Fig. 10.

Acknowledgement

We are indebted to The Bristol Aeroplane Co. Ltd., for the loan of the illustrations accompanying this article.

MAINTENANCE AND OVERHAUL OF POBJOY ENGINES

THE Pobjoy "Niagara III," "Niagara IV," and "Cataract III" engines are of the seven-cylinder air-cooled radial type, with a rated power and speed of 88 b.h.p. at 3,300 r.p.m., 100 b.h.p. at 3,400 r.p.m., and 80 b.h.p. at 3,200 r.p.m. respectively. In the following pages will be found some notes on the recommended maintenance schedule and top overhaul.

MAINTENANCE SCHEDULE

In the following schedule the flying period given applies only to cruising conditions, i.e. where the cruising r.p.m. are at least 300 below the maximum obtainable in level flight with the particular airscrew fitted. Where any part of the flying period is spent at greater throttle openings than this, it should be calculated at double time. Racing at full throttle at maximum permissible r.p.m. should be calculated at three times the flying period given.

Daily

The engine should be given a careful inspection for any obvious defects, and loose parts or any other symptoms of incipient trouble should be rectified as soon as possible.

Twenty-five Hours

The two oil filters, the main fuel filter, and the filter in the base of the carburettor float chamber should be cleaned. The float chamber should be flushed out.

Tappet clearances should be checked, and adjusted if the clearance exceeds 0·010 in.

Rockers and valve springs should be oiled if they appear dry.

Gaskets should be handled carefully when replacing the rocker caps to avoid oil leaks.

In the case of engines fitted with B.T.H. magnetos, one drop of oil should be applied to the contact-breaker rocker pivot. Examine contact-breaker points and wipe them clean, as oil on the points will cause them to pit rapidly.

The oil tank should be drained and refilled with clean oil.

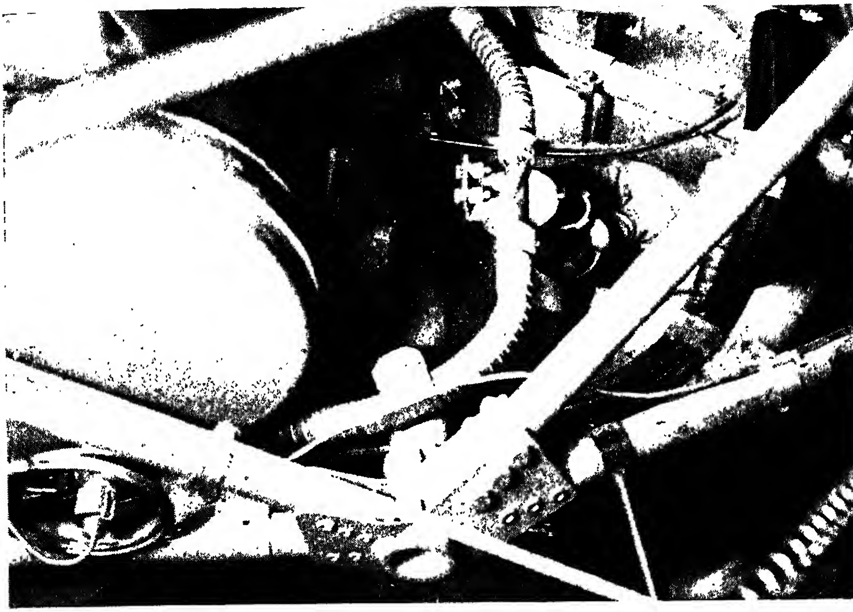

Fig. 1.—CLEAN FUEL FILTERS (1)
Removing main fuel filter in engine nacelle.

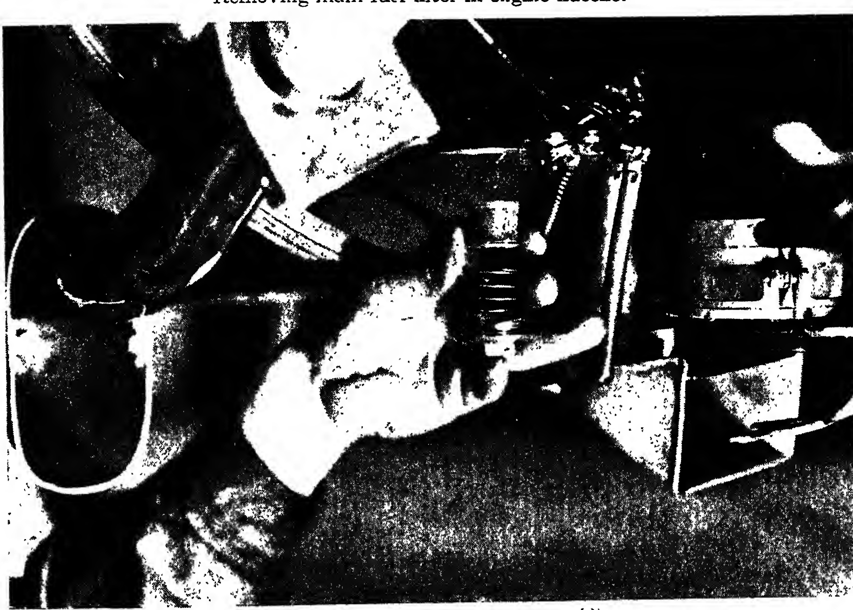

Fig. 2.—CLEAN FUEL FILTERS (2)
Removing fuel filter in body of carburettor.

Fig. 3.—Removing main and power jets from carburettor for cleaning

Fifty Hours

In addition to the items given above, the following operations should be carried out:

The airscrew limb should be checked for tightness on the shaft.

Check that the airscrew bolts are tight.

See that the oil-feed pipe unions are tight.

The sparking plugs should be removed and inspected. They should not be dismantled unless in obvious need of treatment.

The filter caps on the fuel pumps should be examined to see that they are tight, bearing in mind that the washers may occasionally shrink in hot weather, leading to danger of an air lock.

See that the exhaust pipes are fixed securely.

Two Hundred and Fifty Hours

A top overhaul should be carried out if the ground engineer considers it desirable.

Fuel-pump diaphragms should be renewed.

Five Hundred Hours

At this period the engine should be removed from the air frame and be completely overhauled, if possible by the manufacturers.

TOP OVERHAUL

When carrying out a top overhaul, it is not necessary to remove the engine from the airframe.

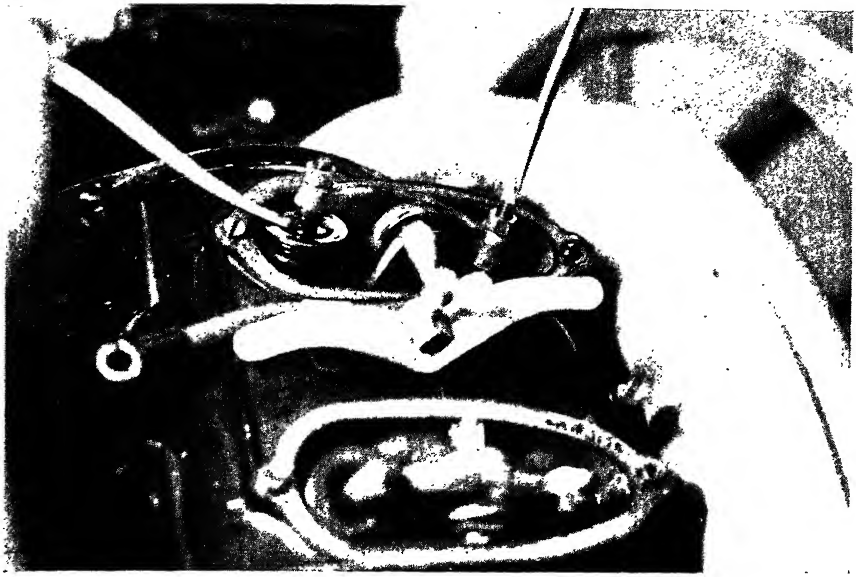

Fig. 4.—CHECK TAPPET CLEARANCES AND ADJUST IF REQUIRED
Adjustment only required if over ·010 in.

Airscrew

First remove the spinner split pin and nut, and remove spinner. Then, with a screwdriver, remove the centrifugal pin and spring locking the central hub nut located inside the hub bore on the end of the airscrew shaft. Insert box spanner, and with the aid of the special tommy bar unscrew the nut (right-hand thread). The nut will come up against the shoulder of the spinner sleeve after about one turn. Further unscrewing of the nut will withdraw the hub off the splines on the airscrew shaft. Hang up the airscrew and its hub in a safe place.

Cowling

The aeroplane cowling should now be removed, followed by the H.T. leads and sparking plugs. Remove the sheet-metal helmet extensions, after unscrewing the two small screws at the rear of the cylinder head.

Exhaust Pipes and Collector Shield

Remove the exhaust pipes and heater pipes. Using the special spanner, slacken the large heater-box nuts. Remove the exhaust collector shield by slackening the screws securing it to the intercylinder deflector brackets, and the air-intake member. The shield may then be passed forward over the engine.

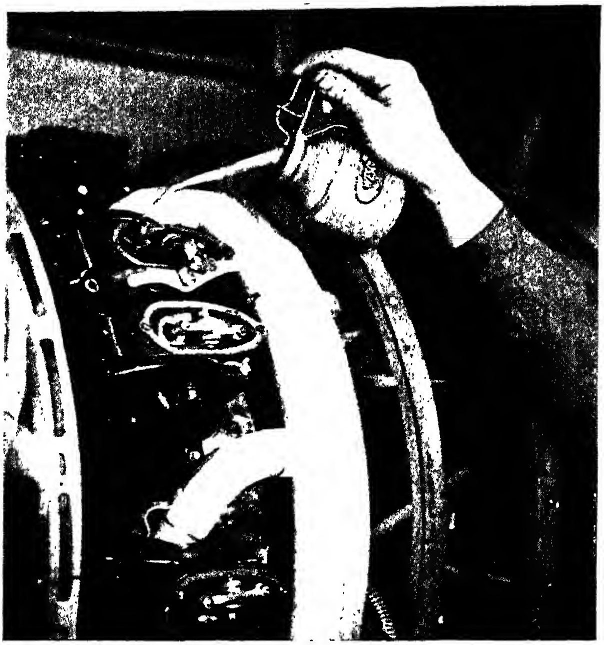

Fig. 5.—Oil rockers and valve springs if dry
This is seldom required as rocker lubrication is very efficient.

Cowling Ring and Intercylinder Deflector

Slacken the ring of setscrews on the inside of the large cowling ring, and detach the latter. After detaching the brackets at the rear of the cylinder-port faces, the inter-cylinder deflectors may be carefully wriggled out. The cowling support ring and the inner nosepiece need not be disturbed.

Inlet Pipe

Disconnect the outer inlet-pipe nuts with the aid of the special spanner. Do not disturb the inner nuts.

Oil Pump

The oil pump should now be removed, because the lowest holding-down nuts of the bottom cylinders are inaccessible with the pump in position. The latter should always be removed before attempting to undo the bottom cylinders ; likewise, the cylinders should be replaced before refitting the pump.

Pushrods

Remove the rocker caps and, by depressing the valves with the hand, remove the pushrods. Chalk the numbers of the cylinders on the bench, and lay out the pushrods accordingly to save unnecessary subsequent readjustment.

Cylinders

The cylinder holding-down nuts should now be unscrewed. Then carefully remove the cylinders, steadying the piston as it emerges. The triangular pushrod casing will come out with the cylinder, and it is not

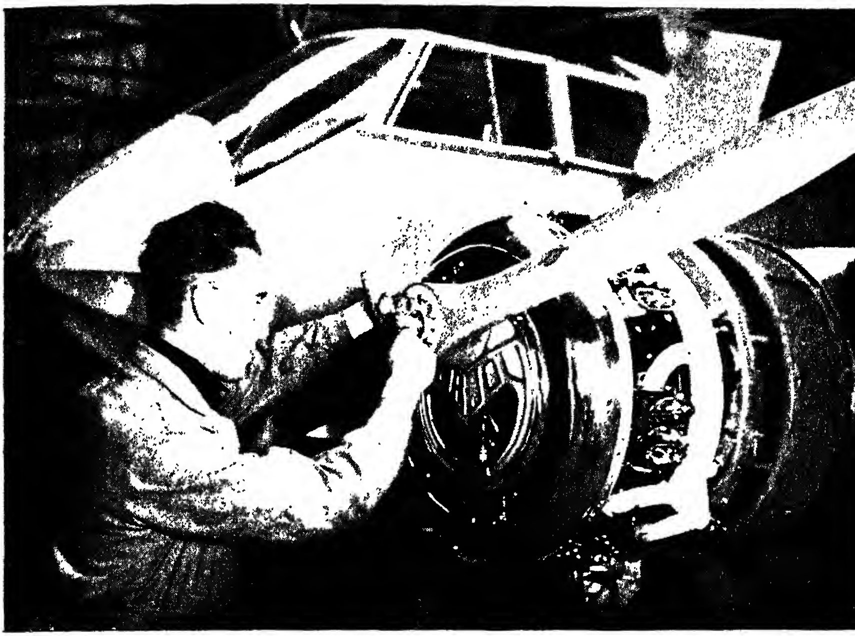

Fig. 6.—CHECK AIRSCREW HUB ON SHAFT FOR TIGHTNESS
A very important item.

necessary to disturb the rubber-lined socket into which it fits on the crankcase.

Pack each crankcase hole with clean rags, so that the connecting-rod is clear of the side of the hole and the piston clear of the holding-down studs. The makers use a simple rubber-covered clip for this purpose.

Holding-down Bolts

The holding-down bolts need not be removed, but they can be extracted, if desired, by pulling out the special stirrup which links two adjacent bolt heads together. These bolts are reduced in diameter for a portion of their length to give some elasticity, and two small semi-cylindrical pressings are fitted around the stem of the bolt to locate it in its hole. In consequence, the bolt may be shaken by hand slightly sideways and pushed downwards against the resistance of the inner stirrup ; it is, however, perfectly secure and rigid when pulled up in position. The locating stirrup is automatically locked up by the cylinder skirt.

Place the cylinders mouth downwards on a clean wooden bench in numerical order. The number is stamped on the face alongside the inlet port.

Fig. 7.—Check airscrew hub bolts for tightness

This should not be overdone as the airscrew is liable to become crushed.

Pistons and Piston Rings

The tagged circlip from the front piston bosses should be removed with a screwdriver and the gudgeon pins pushed out. Remove the piston rings. Place each piston and the fittings alongside their respective cylinder on the bench.

Rockers

Remove the rockers, using the rocker-axis-bolt extracting tool, but do not disturb the rocker brackets.

Valve Springs

Remove the valve split cotters, take off the valve springs, their caps and small loose collars, and punch out the valves.

To facilitate the above operation, it is useful to provide a round-headed wooden peg over which the cylinder will slide and rest on its top. Hand pressure, with or without the special spring compression tool, will then compress the springs sufficiently to enable the split cotters to be removed.

Should it be desirable at any time to remove the cotters, cap, or springs from a valve whilst the cylinder is on the engine, the valve may be held on its seat by the special tool screwed into a sparking-plug hole.

Joints

The joint between the cylinder head and the barrel is a permanent one, and must on no account ever be disturbed. The joint between the duplex rocker box (with roof) and the cylinder head is made by two gaskets of special material and is semi-permanent. It need only be disturbed for

Fig. 8.—Remove and inspect plugs, dismantle and clean if required

Unnecessary dismantling is to be discouraged as the K.L.G. plugs used need very little maintenance.

Fig. 9.—Check exhaust snouts for tightness

This will prevent gaskets from blowing and prevent a lot of wasted time and labour in the long run.

Fig. 10 (*left*).—INSPECT DISTRIBUTORS AND BRUSHES

A light wash-out with petrol is advisable if oil is present on the inside.

renewal of these gaskets occasioned by oil leakage from the rocker casings. The joint between the triangulated pushrod casing and the rear of the

Fig. 11 (*right*).—INSPECT CONTACT-BREAKERS AND RESET POINTS IF REQUIRED

cylinder head is likewise semi-permanent, and is made by two special gaskets.

Decarbonising and Valve Grinding

Decarbonise the combustion chambers and grind the valves in lightly. The seatings are made of special alloy and should be finished off with crocus powder. If a seat is grooved or badly pitted, it should be trimmed with a seating cutter. The angle is 30°.

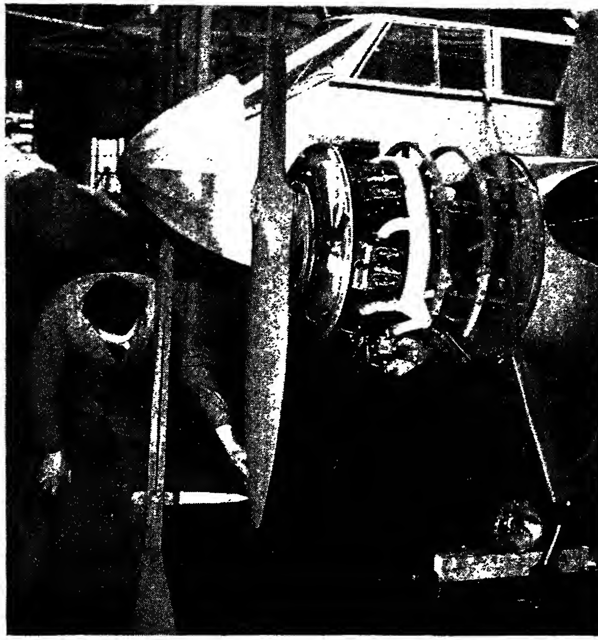

Fig. 12.—CHECK AIRSCREW TRACK

A slightly warped airscrew is often the cause of vibration and bad engine performance.

A badly pitted or grooved valve should be trimmed up at the same angle in a lathe.

Clean the pistons inside and out, not omitting the ring grooves and oil holes.

INSPECTION

After thoroughly cleaning the parts, they should be carefully inspected, paying particular attention to the following points :

Cylinder

Check the bore for wear, ovality, and scoring. Examine the valve-seat inserts for grooving, pitting, or excessive wear. If the latter is present, the cylinder must be returned to the makers for renewal of the seat insert. Alternatively a reconditioned cylinder may be obtained in part exchange for the defective one from the makers or their official repairers.

If the valve guides are worn beyond their permissible limits, they must be replaced. After immersion in boiling water for 15 minutes, they may easily be tapped out and replaced with a soft drift. The exhaust-valve guide is longer than, and not interchangeable with, the inlet guide.

Rocker Gear

Reassemble the cleaned rockers on their brackets and check for wear of the ball races and for end float. The outer races are a floating fit in the rocker, and it is quite in order for them to turn in the rocker. A few thousandths radial slack in the ballraces is permissible, so long as the movement is smooth and the races are not badly pitted.

These ballraces have no cages, and the inner race is detachable. Care must therefore be taken that it does not fall out when the rocker is removed from its bracket, and the balls be lost.

Should the end float exceed the permissible limit, one inner race should

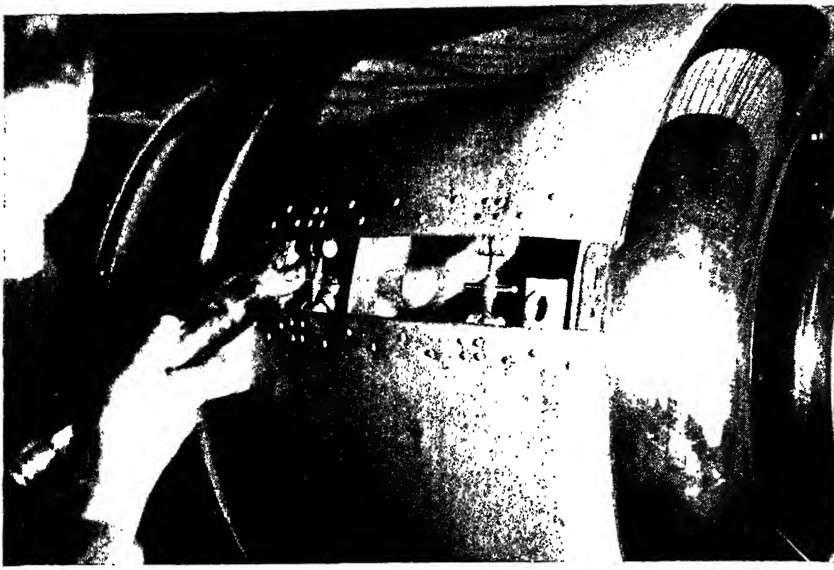

Fig. 13.—Check cowlings and attachments
One faulty rivet may lead to considerable damage if not rectified.

be cautiously removed and a shim taken out between it and the inner collar. Should there be no shim, the collar must be carefully faced down, but not too much, otherwise the balls may be crushed when the rocker is refitted. When the rocker has been refitted to the cylinder, check that it will oscillate freely without signs of binding.

Examine the exhaust rocker adjusting screws for wear. If only slight, they can be stoned smooth, but if serious flats have been formed, they should be replaced. Inspect the ball and socket of the inlet rocker, the pushrod ball ends, and the adjustable rocker sockets; replace if badly worn.

Pistons

Examine for scoring, cracks, wear in gudgeon-pin bores, wear in ring grooves and on skirt. Wear should not exceed makers' minimum and maximum dimensions. Remove scoring with a scraper. Piston rings should be checked for blowing or for excessive gap. If the piston is inserted in the cylinder, the crown can be used for squaring up the ring when checking its gap. Fit the ring to its piston for checking the side clearance of the ring in its groove.

Replacement Piston Rings

The piston (gas) rings when new are ground with a very fine taper, leaving a narrow "land" to bear on the cylinder wall. In service the

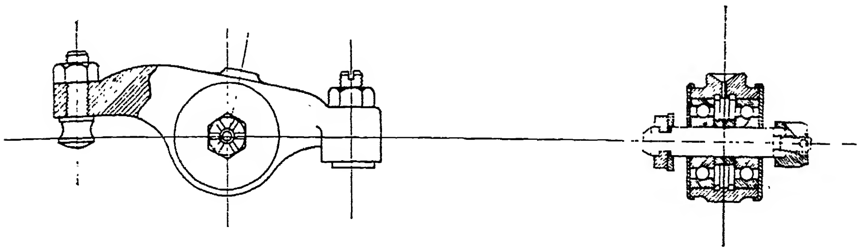

Fig. 14.—DETAIL OF VALVE-ROCKER ASSEMBLY

ring rapidly beds into the cylinder and thereafter bears uniformly against the wall.

When fitting new rings, it is very important that the narrow "land," which has a dull appearance compared with the taper portion, should be on the side of the ring remote from the piston crown.

Gudgeon Pins

Examine for wear and cracks. Check the fit in its connecting rod and piston bores against the limits given in the schedule.

Carburettor

Remove and clean all jets and the slow-running device. Flush out the float chamber with petrol.

Magnetos

Clean and adjust the contact breakers. Inspect and clean the H.T. slip ring and brush.

Distributors

Wash out the inside of the body with petrol. Examine the rotor for looseness of the blade, and replace if defective.

Sparking Plugs

Carefully dismantle, clean, and reset to 0·012–0·015 in. gap. When replacing sparking plugs, the box spanner (provided with the tool kit) should be used with the short (10-in.) tommy bar. Great force is quite unnecessary in tightening, and may lead to the brass adapter seizing on the plug and being withdrawn with it on the next occasion. The special cable terminals, thumbscrews, and spring washers must always be used on the plugs for these engines.

Reassembly after Top Overhaul

The following parts should be replaced by new ones :

Rubber ring below cylinder foot.

Copper-asbestos gaskets on exhaust and inlet ports.

Oil-pump paper gasket and tagged piston circlips if damaged. The following points on reassembly should be noted :

(1) All parts should be freely oiled before assembly.

(2) When replacing the valve springs on the valve, care must be taken that the small loose collar locating the inner spring on the valve-spring cap is correctly fitted ; that is, with its rim bearing on the underneath face of the cap. In later engines, this collar is made of duralumin, and its correct location is obvious.

After assembling the split cotters, check that the assembled valve can be pushed open at least 0·35 in. before the springs close right up.

(3) Reassemble the rockers on their brackets, making sure that the inner distance collar and the outer dust caps are in position, and the inner shims, if any. Oil everything freely. To facilitate the insertion of the rocker-axis bolt, it is desirable to use the special tool provided for the purpose.

The axis bolt should be pushed through the rocker only just far enough to permit of the slotted and recessed hexagon collar being slipped over its slotted end, the plain circular washer having been held against the bracket side as the bolt was pushed face outwards, so that tightening of the axis-bolt nut pulls the bolt head into the recess and so locks it. Check that the rocker will oscillate freely without bending.

(4) Piston-ring gaps should be spaced equidistantly.

(5) The number of the piston is stamped on the web, and the piston must always be replaced with the number to the front. This circlip must lie snugly in its groove. If at all slack or ill-fitting, it must be replaced.

(6) Make absolutely certain that all the piston circlips are correctly in position. Put a new rubber ring over the cylinder skirt, oil the latter, and carefully replace the cylinders.

The number of each cylinder is stamped upon the inlet-port face. Number one is at the top, and the numbers follow around clockwise viewed from the rear. It is very important that the cylinders be replaced in their correct positions, as the master-rod cylinders (No. 4) and its neighbours (3 and 5) have full skirts, while the other four have slotted skirts. If the cylinders are misplaced, the connecting rods will foul the skirts.

(7) Push home the rubber ring and steel sleeve of the inlet-pipe upper joint. Smear a little graphite grease on the nut and thread of the inlet elbow, tighten up, and lock with the special clip.

(8) Refit the oil pump, having previously filled its front chamber with clean oil through the intake union.

(9) The oil pipes may now be recoupled and the washed-out tank filled with clean oil.

(10) When replacing the airscrew and hub upon the airscrew shaft, care must be taken to ensure that the rear steel split cone is pushed back

over the airscrew shaft until it touches the thrower ring in front of the main thrust race. The hub may then be pushed over the shaft until it butts against the cone, and the front nut tightened up on the shaft in the usual manner.

This procedure will obviate any danger of the hub nipping the rear cone before the latter is pushed right home, and thereby allowing the airscrew shaft to float backwards and forwards a little and upsetting the end location of the shaft and gear drum.

(11) Before attempting to turn the engine, a sparking plug in each cylinder should be removed and the engine turned round briskly by hand to clear out superfluous oil. Replace the sparking plugs and start up. Watch the oil gauge to make sure that the oil is rapidly picked up by the pump. If the gauge shows no reading for 15 seconds, it may be necessary to unscrew the inlet oil union and prime the pump. Allow the engine to run slowly for a few minutes before cautiously opening up to 1,500 r.p.m., at which speed it should be allowed to idle for some minutes before opening up.

Note.—The plugs in the lower two cylinders should similarly be taken out before attempting to start if the engine has been standing in the aeroplane for a week or so since its last run.

Acknowledgment

The above notes are based on information supplied by Messrs. Pobjoy Airmotors and Aircraft, Ltd. We should like to take this opportunity of expressing our indebtedness to them for permission to publish this information.

THE CONTINENTAL "W670" ENGINE

NOTES ON MAINTENANCE AND OVERHAUL

THE Continental "W670" Engine is a static, radial, seven-cylinder engine with a rated horsepower at sea-level of from 225 to 250 h.p., manufactured by Continental Motors Corporation, to whom we are indebted for the following information.

ENGINE DESCRIPTION

Crankcase

The crankcase consists of two aluminium-alloy castings bolted together on the centre line of the cylinders. Into the front and rear portions of the case are pressed bearing liners. Ball bearings fit these liners and furnish support for the crankshaft. Intake manifolding and valve-tappet guide bosses are cast into the rear case. A system of drilled oil lines provide pressure oiling to the valve tappets. Engine lifting eyes are attached to the crankcase.

Cylinders

Heat treated, aluminium-alloy cylinder heads are screwed and shrunk to forged-steel barrels. Closely spaced cooling fins are provided on barrels and cylinder heads to give ample and efficient radiation surface. Cylinder bores are ground to mirror finish and held within extremely close limits. Aluminium-bronze sparking-plug inserts and valve seats are shrunk in the cylinder heads. Rocker boxes are cast integral with the heads and provided with oil-sealed covers. Drains are provided on each cylinder for the scavenging of the rocker boxes.

Pistons

Heat-treated aluminium-alloy forged pistons are provided with three compression rings and one oil ring. The heads are internally finned to dissipate heat, and the skirts are exceptionally long to minimise scuffing. Floating piston pins are retained by aluminium plugs.

Connecting Rods

Master and link rods of "H" section are chrome-vanadium-steel forgings completely machined. The crankpin bearing of the internal-type master rod is a diamond-bored, steel-backed, lead-bronze lined

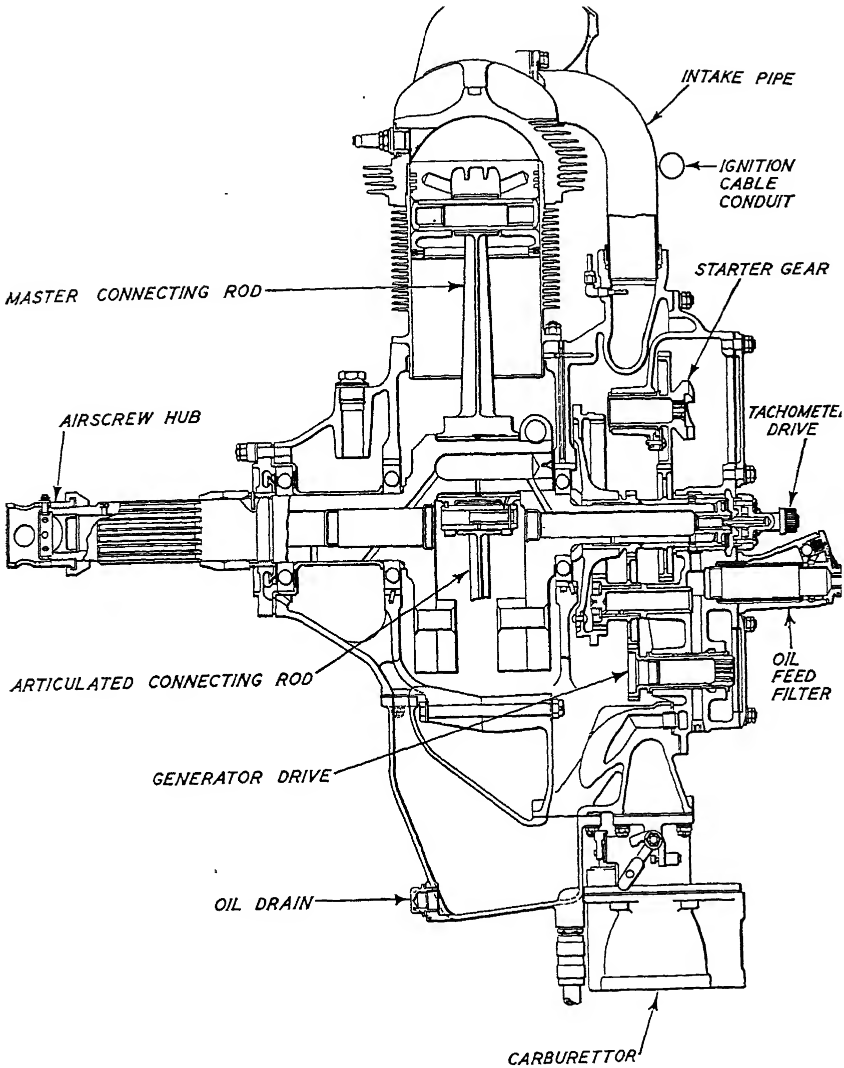

Fig. 1.—SECTION THROUGH CONTINENTAL "W670" ENGINE

bushing. Link rods are attached to the master rod by knuckle pins, which are secured by Woodruff keys and circlips. Piston-pin and knuckle-pin bronze bushings are pressed into the rods and are diamond bored. The master rod is drilled to provide pressure lubrication to knuckle-pin bushings.

LEADING PARTICULARS OF CONTINENTAL "W670" ENGINE

Engine name and type :	Continental Static Radial.
Rated horsepower (Series K and L) :	225 h.p. at sea-level.
Rated horsepower (Series K–1 and L–1) :	230 h.p. at sea-level.
Rated horsepower (Series M and N) :	240 h.p. at sea-level.
Rated horsepower (Series M–1 and N–1) :	250 h.p. at sea-level.
Rated horsepower (Series 6) :	225 h.p. at sea-level.
Rated r.p.m. (Series K and L) :	2,175.
Rated r.p.m. (all others) :	2,200.
Number of cylinders :	7.
Bore :	$5\frac{1}{8}$ in.
Stroke :	$4\frac{5}{8}$ in.
Compression ratio (Series K, K–1, L, L–1) :	5·4 to 1.
Compression ratio (Series M, M–1, N, N–1) :	6·1 to 1.
Piston displacement :	668 cu. in.
Variable-pitch airscrew control (hydro) :	Optional.
Crankshaft rotation from airscrew end :	Anticlockwise.
Cam rotation from airscrew end :	Clockwise.
Tachometer rotation from airscrew end :	Clockwise.
Tachometer drive :	$\frac{1}{2}$ crankshaft speed.
Starter rotation from airscrew end :	Clockwise.
Generator rotation from airscrew end :	Anticlockwise.
Generator speed :	1·2 crankshaft speed standard equipment. $\frac{30}{20}$ crankshaft speed with step-up drive (optional on K, L, M, and N).
Overall diameter of engine :	$42\frac{1}{4}$ in.
Ignition	
Battery or magneto :	Optional.
Battery Ignition—Scintilla, Model WL7A–C1W :	Optional
Magneto Ignition—Scintilla, Model MN7–DF or MN7–DFA (automatic spark advance) :	Optional.
Magneto breaker-point gap :	0·012 in.
Dist. breaker-point gap (battery ignition) :	0·015 in.
Sparking-plug gap (mica plug) :	0·015 in.
Sparking advance (max.) :	32° front plugs, 29° rear plugs.
Oil consumption (max.) :	·025 lb. per B.H.P. hour.
Correct oil pressure at 2,000 r.p.m. :	75 to 90 lb.
Minimum safe quantity of oil :	2 gals.
Maximum inlet temperature of oil :	165° F.
Oil hose connection :	$\frac{3}{4}$ in. I.D. min.
S.A.E. aeronautic standard 6-in. starter mounting and driving jaw.	
S.A.E. aeronautic standard generator-drive mounting.	
Intake valve closes :	21° A.B.C.
Intake valve opens :	8° B.T.C.
Intake valve remains open :	209°.
Intake valve lift :	$\frac{1}{2}$ in.
Exhaust valve closes :	20° A.T.C.
Exhaust valve opens :	63° B.B.C.
Exhaust valve remains open :	263°.
Exhaust valve lift :	$\frac{1}{2}$ in.

(Above timing represents engine hot or 0·055-in. clearance intake and 0·070-in. clearance exhaust.)

Clearance at valve—valve to rocker roller (cold)	0·010 in.

Crankshaft

The crankshaft is a two-piece, heat-treated, chrome-nickel-steel forging drilled throughout for lightness and plugged to form oil passages. The shaft is of one-throw design and completely machined. The crankpin is accurately ground to size and fitted to a ground hole in the rear cheek, where it is clamped in place. Steel counterweights are straddle fitted to the crankcheeks and riveted in place. The shaft is supported by two ball bearings. A ball bearing at the forward end provides end location. Bearings are held by clamping action of nuts, spacers, and sleeves. The driving end of the shaft is machined to a No. 20 S.A.E. spline, except for length.

Cam Ring and Drive

The cam ring is a nickel-steel forging, completely machined and hardened. Intake and exhaust cam surfaces are side by side with three cam lobes each. The cam ring is riveted to a heat-treated forged aluminium-alloy hub, which is carried on the sleeve of the cam-drive gear and turns at one-sixth engine speed in the opposite direction to the crankshaft. On the inside rim is an internal gear, which meshes with the cam-drive intermediate gear, which in turn is driven from the cam-drive crankshaft gear.

Valve Gear

Rollers and tappets fit aluminium-alloy guides so sealed as to prevent leakage. Tappets are drilled in such a manner that an oil passage is provided from the tappets to the push rods, rocker-arm bearings, and rocker rollers. Push rods are made of light-steel tubing with welded ball ends, hardened and ground, and drilled their entire length to provide an oil passage to the overhead mechanism. The push rod is fully enclosed, and the outer end fits into an adjustable socket in the rear of the valve rocker. The rocker acts directly on the valve through the roller, and effectually prevents side thrust on the valve stem. Rockers are mounted on double-row replaceable ball bearings, and are completely enclosed. Push rods are withdrawn through the rocker arms by removing the adjusting screw sockets from the rockers.

Accessory Case

The accessory case is a light-alloy casting which is attached to the rear of the crankcase. It contains the entire accessory gear train. It provides standard S.A.E. flanged mountings for two magnetos, starter and generator, and fuel pump. It also carries a double tachometer drive, pressure oil pump, separate scavenge pumps for engine sump and rocker boxes, pressure oil filter, scavenge oil strainer, oil-pressure relief valves, and oil temperature connection.

Intake System

Fuel mixture may be provided by a single carburettor or specially developed fuel injector (optional).

Carburettor Model.—The carburettor is attached directly to the intake manifold passage cast in the crankcase. Separate intake pipes connect the manifold with each cylinder. Carburation is excellent throughout the entire range without the use of blower mechanism. A suitable heating device is required for cold-weather operation.

Fuel Injector Model.—The injector consists of a compact unit housing seven (7) individual plungers operated by a swash plate. These plungers meter and distribute fuel to each cylinder separately. The injector is driven from a separate unit, which houses the generator and injector drives and is attached to the accessory case. The air throttle is attached to the manifold passage, and is connected by linkage to the metering pin in the injector. Fuel lines which lead from the injector to the cylinders are of extra heavy copper tubing covered with " Neoprene " rubber. All lines are provided with suitable brackets and attachments, so that they are securely held to the engine in their travel to the nozzles, which are located in the intake pipe near the cylinder port. Due to the total absence of icing conditions and improved distribution, no heating device is necessary even for the coldest-weather operation.

Exhaust System

The " W670 " engine may be obtained with either front or rear exhaust outlets. To the rear exhaust outlets there are attached deeply finned elbows. These elbows provide for the convenient arrangement of a suitable exhaust collector ring. On front exhaust models, the exhaust collector ring is attached directly to the cylinders.

Lubrication

The " W670 " is a dry-sump engine. Oil is drawn from the oil tank, filtered, and delivered under pressure through drilled passages in the accessory case to all drive bearings and through the crankshaft to the crankpin and knuckle-pin bearings. Engine oil from the main pressure pump under reduced pressure is carried through drilled passages in the crankcase to the tappets. After entering the tappets, it travels out to the overhead mechanism through hollow push rods, and flows over the rocker-arm bearings and rollers. As it drains away, it thoroughly oils the valve stems and valve guides. From the upper three cylinders, the oil is returned to the crankcase by the push-rod housing ; while from the lower four cylinders, it is drained to the lowest point and there picked up by a special scavenge pump mounted on the accessory case, and returned to the engine sump.

Cylinder walls, crankshaft thrust and main bearings, and piston-pin bearings are lubricated by a spray. Gear-type feed and scavenge oil

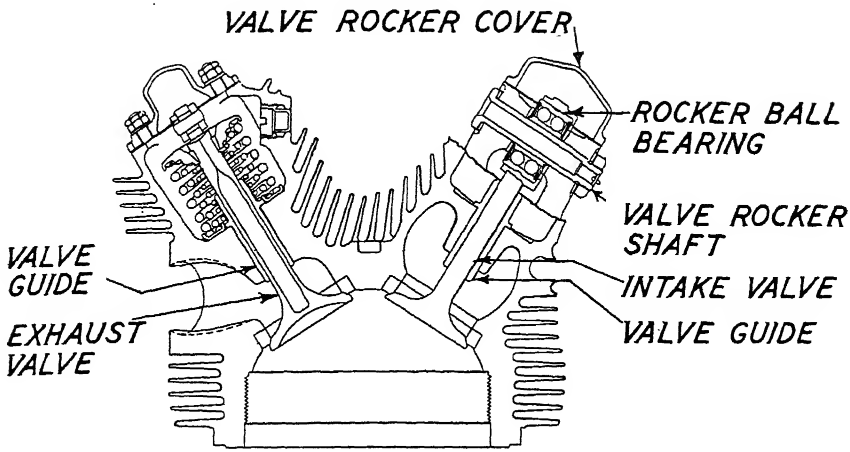

Fig. 2.—SECTION THROUGH VALVES

pumps are provided. Scavenge pumps pick up excess oil in the crankcase sump and rocker scavenge tee, and return it through a coarse-mesh screen to the oil tank. The main-pressure relief valve is set to give approximately 70 lb. oil pressure at 2,000 r.p.m., while the auxiliary pressure relief valve regulates the overhead oiling system to 15–20 lb. pressure.

Testing

Every engine is run five or more hours, of which one hour is at full throttle with aircrew load, after which it is completely disassembled and inspected. It is then reassembled and given an additional three-hour check run at full load, full throttle. The thoroughness employed in testing production engines is a safeguard to Continental quality. Performance of engines in the field amply justifies the care expended in proving the engine's right to bear the Continental winged seal of quality.

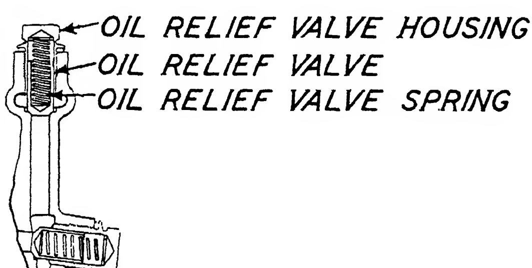

Fig. 3.—SECTION THROUGH HIGH- AND LOW-PRESSURE RELIEF VALVES

Starter

The engine is equipped with an Aeronautical standard starter drive, to which may be attached any standard starter. Electric starters are preferable ; but if an air starter is to be used the bosses provided on the cylinders for the attachment of the air lines will have to be drilled and tapped.

Tachometer Drive

The engine is equipped with two tachometer drives pointing to the rear and conforming to Aeronautics S.E.A. standard dimensions.

Generator Drive

The engine may be equipped with a generator speed step-up drive unit, which has a standard S.A.E. Aeronautic generator mounting.

When the engine is equipped with the speed step-up drive unit, the generator speed is increased to $\frac{39}{20}$ crankshaft speed. Without the generator step-up drive, the generator speed is 1·2 crankshaft speed.

Fuel-pump Drive

The engine is equipped with a standard Air Corps type fuel-pump mounting flange.

OPERATION

Before starting the engine, it is essential that the right grades of fuel and oil be obtained.

Fuel

The high-compression engines (6·1 to 1) require not less than 78-octane fuel, while the low-compression engines (5·4 to 1) require not less than 65-octane fuel. Improved operation is obtained by using 80-octane aviation fuel for the high-compression engine and 73-octane aviation fuel for the low-compression engine. Operation with inferior fuel will result in burned pistons, excessive sparking-plug deterioration, pre-ignition, and other troubles.

Lubrication Oil

It has been found that the best lubricating oil is the cheapest in the long run. Oil of proper viscosity must be used. It must be free from acid, have a low cold test, and leave a minimum amount of carbon in the combustion chamber. Incorrect oil may result in excessive wear on various parts, carbon formation, and high oil consumption. Oils should conform to U.S. Army Air Corps specification 3556-C.

The engine lubrication system should be filled with a standard brand of aviation oil, having a viscosity of 95 to 105 second Saybolt at 210° F. or grade 98 of above Air Corps specification for your round usage when the indicated oil-operating temperature does not exceed 180° F. For temperatures above this figure, 110 to 125 second oil should be used.

Since the rocker arms and all overhead-valve mechanism is automatically oiled under reduced pressure from the main engine pump, no special oiling is required for these parts. The rocker boxes should be kept clean and free from heavy lubricants.

Oil Pressures and Temperatures

The oil gauge should show a pressure of 75 to 90 lb. at 2,000 r.p.m. engine speed, and the oil temperature register 120° F. to 180° F. or 50° C. to 90° C.

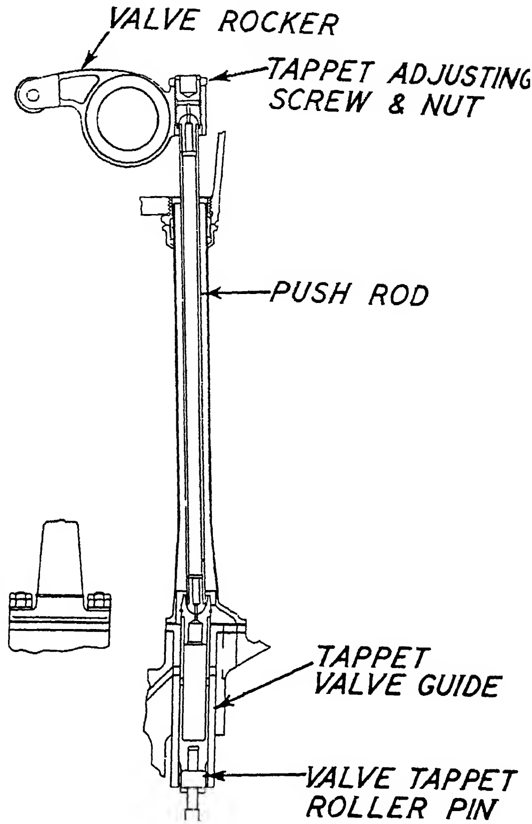

Fig. 4.—SECTION THROUGH VALVE TAPPET AND PUSH ROD

Mixture Control (Carburettor Models)

The carburettor is designed to deliver a richer mixture to the engine at full throttle than at part throttle in order to avoid cylinder and valve overheating under severe conditions of service, and to obtain maximum power.

If altitudes above 5,000 ft. are encountered, the decreased density of the air may cause the mixture to become too rich for best power. This may be investigated by moving the mixture control from the "full-rich" position while checking the constant load r.p.m. If the speed does not increase as the mixture is made leaner, the control should be returned to the "full-rich" position. If manual operation of mixture control is not provided, control lever on the carburettor should be wired in "full-rich" position.

For average operation below 5,000 ft. altitude, the control should be left in the "full-rich" position. When at part throttle, the fuel consumption

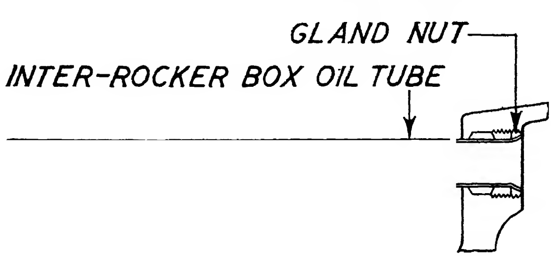

Fig. 5.—SECTION THROUGH INTER-ROCKER BOX TUBE FOR CYLINDERS, 3, 4, 5 AND 6

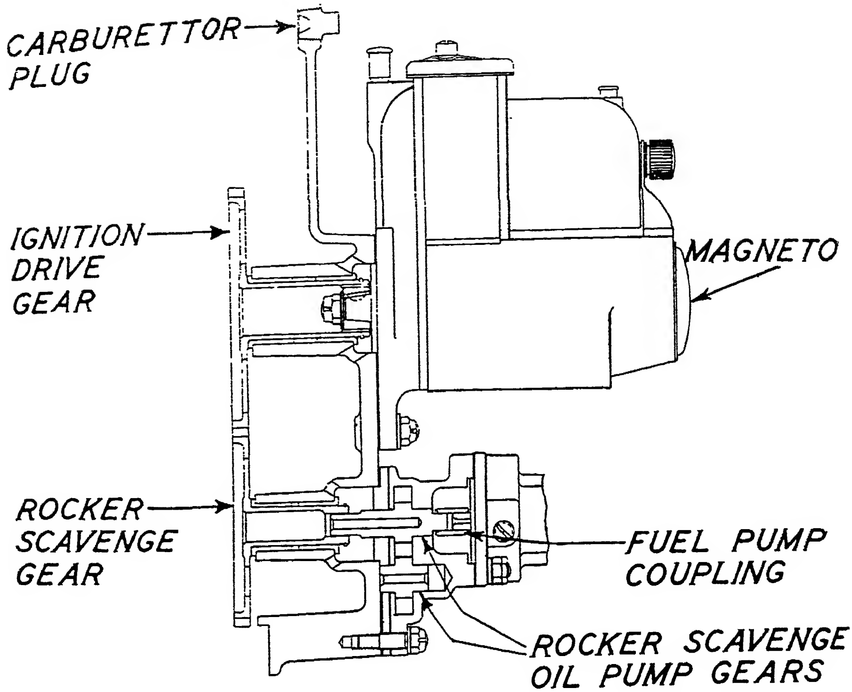

Fig. 6.—SECTION THROUGH MAGNETO DRIVE, ROCKER SCAVENGE AND FUEL PUMP DRIVE

may be improved by leaning the mixture, but in no case should the control be moved far enough to decrease the engine speed. The control should always be moved back to the " full-rich " position before returning to full-throttle operation. It should be remembered that " leaning " the mixture will cause the engine to run hotter, and it should therefore be attempted *only* when load and weather conditions appear to warrant it.

Carburettor Air Heater (not used with Fuel Injection Models).

In addition to using a carburettor air heater, in some installations, to improve operation in cold weather, it will also be useful in preventing ice forming around the carburettor throttle when the temperature is low and the humidity high. An air valve which allows cold air to enter the heater pipe may be adjusted so that the proper mixture of hot and cold air is supplied to the carburettor to obtain the best operating results.

Spark Advance

Optional equipment on all models includes manual-control or automatic-spark advance magnetos. The automatic-spark advance magnetos

will have been set at the factory to give desirable starting and idling characteristics, and no further control equipment is required for these units.

When manual-control spark-advance magnetos are used, a control should be placed in the cockpit or the control arms wired in the full-advance position.

Engine Cooling

Maximum temperature of cylinder heads should not exceed 500° F. Maximum temperature of cylinder barrels at hold-down flange radius should not exceed 300° F.

Stopping Engine

After completing any run, the engine should be idled for several minutes before stopping, thus allowing the cylinders to cool gradually.

MAINTENANCE

Maintenance Tools

A tool kit furnished with each engine facilitates the making of minor adjustments. It consists of the following items :

Tool roll and strap.
Feeler gauge for valve clearance.
Wrench for valve-adjusting screw.
Wrench for valve-adjusting screw nut.
Magneto wrench (furnished with magneto), $\frac{1}{4}$ in.
Dwarf "boxocket" wrench, $\frac{7}{16}$ in. and $\frac{1}{2}$ in.
Combination pliers, 6 in.
Sparking-plug socket wrench, 1 in. and $\frac{11}{16}$ in.
Grease gun, $1\frac{1}{2}$ in. diameter.
Screwdriver, 6 in. and $\frac{5}{16}$ in.
Valve-spring compressor.
Intake-pipe gland wrench.
"Boxocket" wrench for cylinder nuts, $\frac{1}{2}$ in.
Crossbar, ferret, 10 in. $\times$ $\frac{3}{8}$ in.
Wrench for crankshaft hub.
Wrench for push-rod housing gland nut.
Wrench for push-rod housing retainer.

Inspection before each Run

In helping to increase the engine's dependability, it will be found advisable to make the following inspections and adjustments :

(1) Check fuel and oil levels in their respective tanks.

(2) Check fuel and oil lines for loose connections.

(3) See that the oil temperature is at least 100° F. or 38° C. before operating the engine at full throttle.

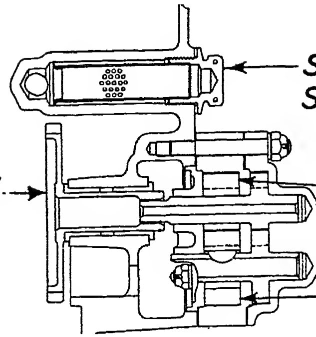

Fig. 7.—SECTION THROUGH OIL PUMP AND SCAVENGING OIL STRAINER

(4) Be sure the oil-pressure gauge registers 75 to 90 lb. at 2,000 r.p.m. engine speed.

(5) Test the ignition by running on each unit alone.

OVERHAUL (every 500 hours)

Due to the modern improvements and engineering features of the Continental " W670 " engine, required maintenance has been reduced to a minimum. As a general rule, the " W670 " will need only the engine check at 100 hours, and a major overhaul at approximately 500 hours. The operating time before a major overhaul is, of course, greatly dependent upon the care the engine has been given, and the type of service to which it has been subjected.

No general top overhaul is recommended, but if a valve begins to leak or the engine performance falls off, the cylinder causing the trouble should be located and removed, and the condition corrected. However, if the engine behaviour indicates that special maintenance is needed before a major overhaul, it will be well to make a careful check of all controls, sparking plugs, mixture and spark-setting, ignition-breaker points, valve timing and clearance, and fuel system, to make sure that poor functioning of one of these is not affecting the performance.

ENGINE CHECK (every 100 hours)

An engine check is done without removing the engine from the aeroplane, and is as follows :

(1) Inspect for oil leaks. Any undue amount of oil appearing at any point on the engine is an indication of trouble and should be thoroughly investigated.

(2) Check all engine mounting bolts to see that they are tight. Inspect fuel and oil lines for breaks or loose connections. Check control linkage for undue wear, missing cotter pins, and to see that full travel of all controls is obtained.

(3) Remove and clean the scavenge oil strainer located to the right and above the oil-pump assembly. Remove and clean the fuel strainer. Remove and clean oil filter and pressure relief valves.

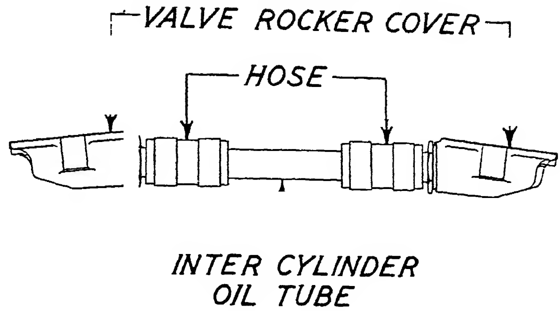

Fig. 8.—View showing inter-cylinder rocker scavenge connections for cylinders 3, 4, 5, and 6.

(4) Remove the rocker covers and wash the valve stems with kerosene by injecting it upon the stems with an oilcan. Work the kerosene in so that any dirt and gum deposit will be washed off. After treating with kerosene, the valve stems should be oiled.

(5) Reset valve clearance to 0·010 in. cold.

(6) Check the sparking plugs.

(7) Inspect ignition breaker points and reset to proper clearance.

(8) Wash the engine thoroughly with a cleaning fluid, preferably non-inflammable, to avoid fire hazard.

MAJOR OVERHAUL

Tools

In addition to the regular maintenance tool kit, a number of special major overhaul tools are required for the major overhaul work.

Dismantling

The engine must be removed from the aeroplane. A clean table should be provided on which the engine parts may be arranged for inspection as they are removed and cleaned. Keeping parts grouped according to cylinders and assemblies will greatly facilitate the inspection and subsequent assembly operations.

Do not stamp numbers on parts for identification on assembly, as failure of such parts may be caused by cracks originating at the marks made by the numbering die. Small paper tags may be used for identifying and locating the parts not numbered by the makers.

Dismantling procedure is as follows :

(1) Remove the engine and place on a suitable stand. First, however, disconnect all oil and fuel lines, thermometer connections, tachometer-drive shaft, air lines, ignition wires, generator earth wires, and all engine controls. An engine lifting beam is attached to the lifting eyes on either side of No. 1 cylinder, and the engine weight taken on a chain hoist. Mounting bolts are then removed, leaving the upper ones to the last.

The engine is swung out of its mounting ring, care being taken to avoid striking any of the accessories during the procedure. It is then attached to an assembly stand with not less than four bolts.

(2) Remove all baffling, radio shielding, and ignition harness from the cylinders.

(3) Remove the exhaust manifold.

(4) Remove the sparking plugs and shields.

(5) Remove the scavenge oil lines connecting the lower rocker covers.

(6) Remove the oil sump.

(7) Unscrew the push-rod housing gland nuts from the cylinder with the special wrench provided in the maintenance tool kit, but do not attempt to remove the housings before the cylinders are removed.

(8) The intake-pipe gland nuts should be unscrewed with the special wrench which will be found in the maintenance tool kit.

(9) Remove the palnuts, then remove the cylinder hold-down nuts with the special wrench which will be found in the maintenance tool kit.

(10) Pull off cylinders, leaving No. 1 cylinder to the last. It is advisable to remove each cylinder when the piston is at the top of the compression stroke for that cylinder. Great care should be exercised to prevent pistons dropping against the crankcase and being dented or marred. It is suggested that the cylinders be removed in the following order: 3–5–7–2–4–6–1. Intake pipes must be carefully handled, as they are easily dented. As soon as each cylinder is removed, its intake pipe should be taken off so that it will not be damaged during subsequent operations.

(11) Each piston should be taken off as soon as its cylinder is removed. If the piston is at the inner end of the stroke, it must be brought out by turning the crankshaft. The piston must be carefully supported during this operation to prevent the lower piston ring from catching on the crankcase opening. The piston pin should be a light push fit at 70° F. and may be tapped out with a round brass bar. If the pin sticks, due to cold weather or other reasons, the piston may be heated in order to remove the pin. While pushing out the pin, the piston should be supported to prevent straining the connecting rod.

(12) After the cylinders are all removed, the push rods and push-rod housings can be dismantled from the crankcase by removing the two nuts at the base of each housing. These parts should be arranged so that they may be returned to their respective positions on reassembly. Check push-rod length for wear. Original length is 10·920 to 10·940. If worn more than 0·020 in., replace. Ends must be file hard.

Removal of the Valve Rocker Arms

(13) Remove the valve rocker cover. The cylinder is bolted to the holding plate with four bolts. When it is in position, the cotter pin and nut are removed from each valve rocker shaft. The shafts are tapped

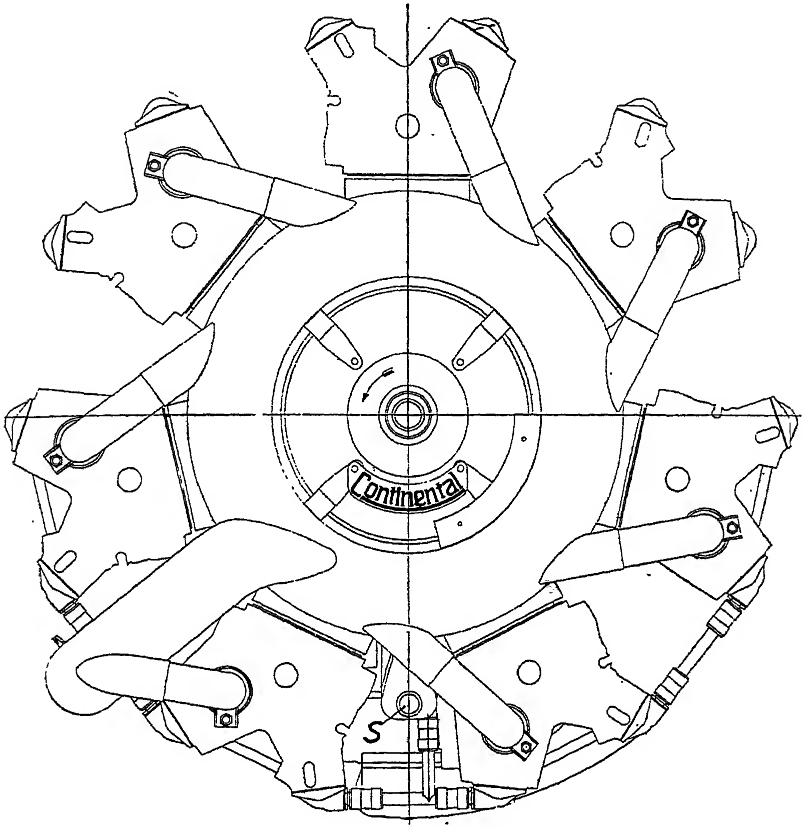

Fig. 9.—Diagrammatic view of front of Continental "W670" engine
S is the oil drain plug.

out with a $\frac{3}{8}$-in. aluminium bar. The valve-adjusting screws and locknuts should be unscrewed from each rocker arm and, together with the shaft and rocker arm, should be laid out so that they can be returned to the same position on reassembling the engine.

Removal of Valve Mechanism

(14) With the cylinder still bolted to the holding-down plate, the valve-spring compressor is pinned to the valve-rocker shaft holes in the rocker box, and each valve spring is compressed and the valve springs removed. Circlips at the upper end of each valve are taken off, and if the circlip groove is burred, it should be smoothed off with a fine file before pulling it through the valve guide. The valves are removed, being careful that they do not scratch or mar the cylinder wall.

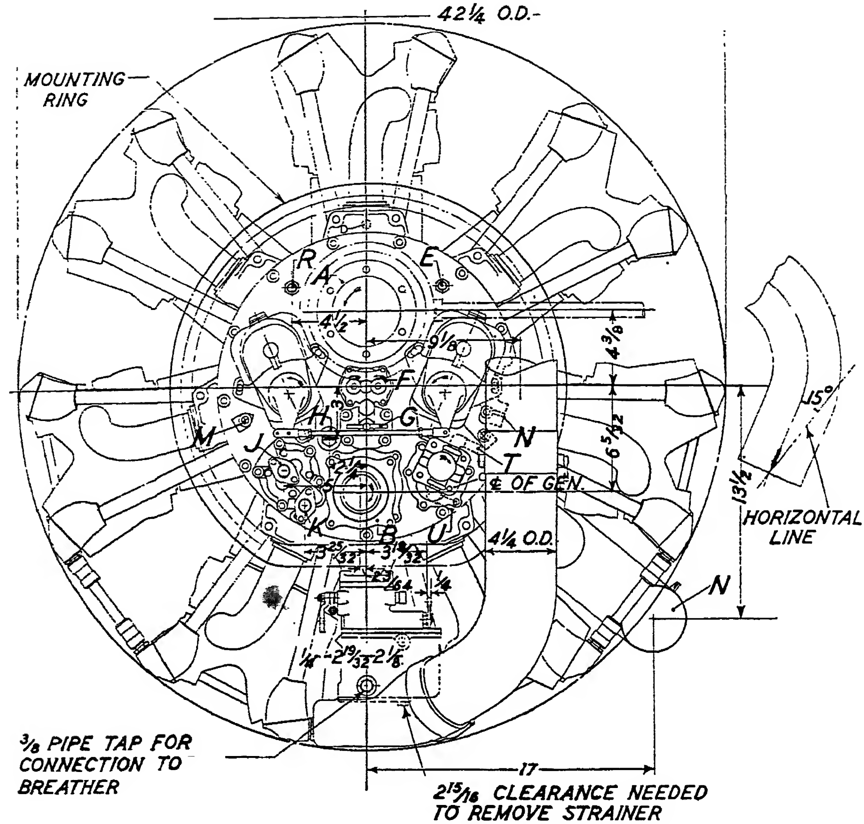

Fig. 10.—Rear view of Continental "W670" engine

Key to Figs. 10 and 11. A—Starter mounting, S.A.E. Std. B—Generator mounting. E—Oil tank conn., ½ I.D. hose. F—Dual tachometer drive, S.A.E. Std., ½ crankshaft speed. G—Feed oil filter, Cuno. H—Scavenge oil filter. J—Inlet oil conn., ¾ I.D. hose. K—Outlet oil conn., ¾ I.D. hose. M—Oil-pressure gauge conn., ⅛ pipe tap. N—Exhaust outlet conn., 4 O.D. P—Crankshaft end, Air Corps Std. No. 20 airscrew attaching parts, A.N. Std. R—Breather conn., ½ I.D. hose. S—Oil drain. T—Fuel pump outlet. U—Fuel pump inlet. CG—Centre of gravity, without starter and generator.

(15) Remove rings from the pistons, care being taken not to scratch or mar the surface of the pistons.

(16) Detach starter, generator, tachometer drive, and fuel pump and other accessories from their respective flange mountings.

(17) Remove the magnetos or distributor units.

To remove the Accessory Case

(18) First, remove all the nuts attaching the accessory case to the crankcase. Through the opening uncovered by removing the tachometer

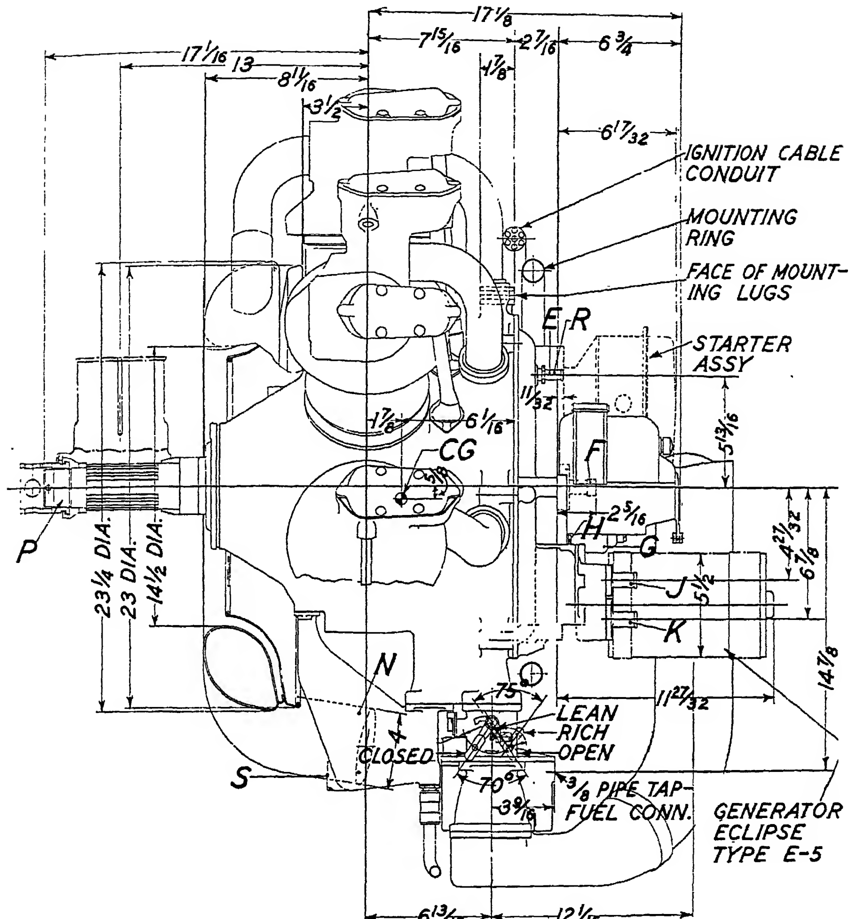

Fig. 11.—SIDE VIEW OF CONTINENTAL "W670" ENGINE
For key to letters see Fig. 10.

assembly, access to the rear crankshaft nut is obtained. The wire circlip on the rear crankshaft nut is pulled off, and the tongued locking washer is removed. With a socket wrench, the crankshaft nut is screwed to the rear, thus breaking the serrated drive between the crankshaft starter gear and the crankshaft-cam drive gear. This nut must be backed completely off, which will in turn force a separation between the accessory case and crankcase. The whole accessory case, with gear train intact, is then free to be lifted off as a unit.

(19) Unscrew the thermometer bulb from its connection in the pressure

oil filter located just below the centre of the accessory case ; remove the filter, thoroughly clean out the sludge collected in the filter housing.

(20) Remove the scavenge oil strainer located above and to the right of the oil-pump assembly, and thoroughly clean in petrol.

(21) Detach the oil-pump assemblies. The pumps can then be dismantled and the shafts and gears taken out.

(22) Dismantle gears from accessory case. Remove the circlips on the rear end of the ignition drive shafts, thus allowing the shafts and integral magneto gears to be slipped out of the front side of the accessory case. The same procedure is followed in removing the oil-pump drive gears. The cotter pin and nut are removed from the cam-drive intermediate gear, which can then be slipped off the cam-drive gear pin. It is not necessary to remove the pin. To remove the starter gear, insert a screwdriver through the starter opening in the accessory case, and turn the gear until the holes in the gear web are in line with the screws fastening the gear retainer to the case. Remove these screws, and the retainer and gear can be moved to the rear of the case and tilted upward through slots in the starter opening in the accessory case.

Remove the Cam Ring

(23) When the accessory case has been taken off, the crankshaft-cam drive gear and the cam ring, which bears upon the sleeve of the drive gear, can be slipped off the shaft. The crankshaft rear bearing washer can also be removed at this time.

Remove Valve Tappets and Guides

(24) After the cam ring has been removed, the cam-following mechanism may be dismantled by first removing the circlip and then pushing the tappet through the guide sufficiently far to remove the roller pin from the tappet. When this is done, the roller may be removed and the tappet withdrawn. Tappet guides are dismantled by first removing the nut on each tappet flange, and carefully tapping the guide out with a rawhide hammer.

Dismantle Crankcase

(25) The crankcase bolts between each pair of cylinders should be removed, using a special crankcase bolt puller. These bolts are closely fitted to maintain the alignment of the front and rear sections of the case. The bolts should be backed out, using a socket wrench until there is room enough to insert the jaws of the puller under the bolt head. Using this tool to maintain tension on the bolt, continue to back it out until free. The crankshaft, front crankcase section, and master-rod assembly may now be removed from the rear crankcase section as a unit.

Dismantle the Crankshaft

(26) The rear end of the crankshaft should be placed in a special rear crankshaft bench support which should be located in a low bench. The crankshaft-bearing nut lock ring should be removed, after which the front crankcase cover plate can be detached. The crankshaft bearing nut can then be unscrewed, using a special wrench for this operation. Slip off the oil thrower. The crankshaft bearing puller should be bolted to the studs at the front of the crankcase and the spindle screwed into the end of the crankshaft. Turning the driving nut of the tool will draw the front crankcase over the crankshaft. The front thrust bearing should not be removed from the crankcase unless defective. The intermediate bearing may be removed from the crankshaft by bolting the two adapter blocks to the bearing puller and using threaded adapter on spindle, after which the tool is operated as described above. The crankshaft rear bearing is pulled in the same manner, after mounting the splined end of the shaft in a special front crankshaft bench support.

To dismantle the crankshaft, a special crankshaft clamp-bolt wrench should be used to unscrew the clamp bolt. This bolt should be backed out of the threaded portion and reversed. The special crankshaft rear cheek spreader should then be inserted in the unthreaded portion with the pin towards the centre of the slot in the shaft and the clamp bolt brought up snugly against it. Usually a quarter-turn from this position will free the crankpin. Do not turn the bolt more than is just necessary to free the crankpin. As soon as the front portion of the crankshaft is dismantled, the pressure on the clamp bolt should be removed. The master-rod assembly can now be removed.

Dismantle the Master-rod Assembly

(27) The assembly is mounted on a master-rod bench support and the knuckle pins are pressed out after the circlips have been removed.

NOTES ON INSPECTION

It is well to check valve springs for tension before installing in the engine. When compressed to $1\frac{3}{8}$ in., the outer spring should show 75 lb. When compressed to $1\frac{9}{32}$ in., the intermediate spring should show 60 lb. When compressed to $1\frac{1}{16}$ in., the inner spring should show 32 lb. Compression loads are subject to 2 lb. variation.

After the valves have been installed again in the cylinder, they should be tested for tightness by completely filling the port openings with petrol, and inspecting around the valve heads for leaks.

Rocker Arms

The rocker roller should turn freely on its pin bushing. Any rollers which are worn out of round or have excessive clearance on the roller bushings should be replaced. To replace any of these parts, it will be

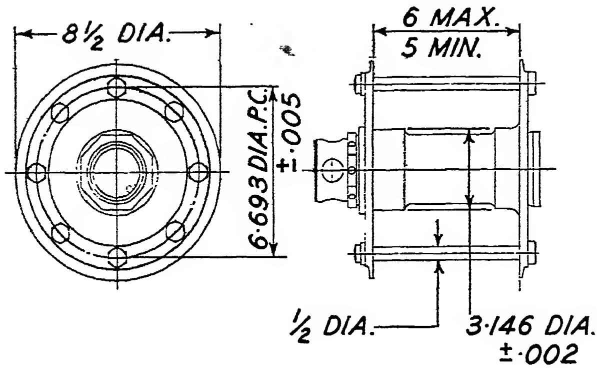

Fig. 12.—Details of wood airscrew hub

necessary to file off one end of the roller pin so that it can be driven out with a punch. A new roller and pin bushing can then be installed and a new pin riveted in place. Adjusting screws whose slots have been badly burred by adjusting tools should be replaced.

Check ball-bearing looseness by clamping bearing inner race on a rocker shaft, after it has been thoroughly washed, and trying rocker for side play without oiling. Side play should not exceed 0·005 in. indicator reading at the roller axle. Oil the bearing and try for smoothness. It should give no indications of roughness. A further check is necessary after replacing arm in rocker box. If it should be necessary to replace the ball bearing, this may easily be accomplished by simply pressing out the old bearing towards the side without the shoulder, and pressing in the new. In pressing in the new bearing, care should be taken to see that no burrs are present on the contracting surfaces, and that the bearing seats properly in the rocker arm.

Intake Pipes

Replace any intake pipes which are badly dented, as dents may interfere with the flow of the charge into the cylinder and cause loss of power. The flanged ends of these pipes should be examined for cracks. The pipes should be checked for leaks by filling with petrol after they have been attached to the cylinder.

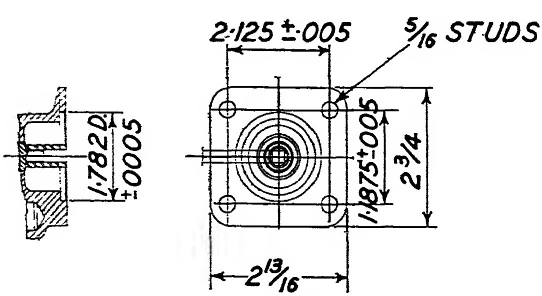

Fig. 13.—Details of fuel pump adapter

Piston, Pin, and Rings

Carbon should be carefully cleaned from piston heads. Carbon in the ring grooves may be removed by scraping the grooves with the squared end of a broken piston ring. The pistons should be carefully examined for cracks and any nicks or burrs. Scratches on

the thrust faces should be carefully stoned out with a fine flat stone, but deep scores will necessitate replacing the piston.

The piston rings should be checked for tension, gap clearance, side clearance in the grooves, and for feather edge. The tension is measured by placing the ring on edge with the gap horizontal on a platform scale and noting the scale reading when the pressure on the ring is just sufficient to close the gap. This should not be less than 5 lb. If a scale is not available, some idea of the tension may be obtained by checking the gap with the ring free. This gap should be at least $\frac{7}{16}$ in.

The gap clearance may be checked by placing the ring in the cylinder, using a piston as a support to keep the ring square while a feeler gauge is used to measure the gap. If gap exceeds 0·035 in., the ring should be discarded. Each ring is checked for side clearance in its own groove. If the edges of the rings are slightly feathered, but otherwise good, the rough edges may be removed by passing a fine stone lightly over the rough parts.

Before assembling the oil control ring in its groove, the oil drain holes in the bottom of the groove should be cleaned. The slots in the ring should also be opened if clogged by oil or carbon. The rings should be turned so that the gaps are equally spaced around the piston before assembling.

Piston pins should be checked in their respective connecting rods and should not have more than 0·003 in. clearance in the rod bushings.

Piston-pin plugs should be inspected for tightness and replaced if loose.

Ignition Wires

The ignition wires should be inspected for cracks in the insulation, especially where the wires leave the ignition conduit. Defective wires should be replaced by attaching the new wire to the end of the old, covering the joint with friction tape, and pulling the new wire into place. The magneto ends of the ignition wires are marked, to indicate their firing order and not the cylinder number to which they are attached. Thus, wire to cylinder No. 3 is stamped No. 2, because it is second in the firing order, etc. The longer of the wires at each cylinder is attached to the front sparking plug. Ignition cable two years old should be replaced.

Sparking Plugs

Check all plugs to detect damage in the insulation. Set sparking-plug points to 0·015 in. Clean thoroughly, and replace plugs whose points are too badly burned or where the insulation is damaged.

Magneto

After the engine has been reassembled, the magneto breaker points should be checked. The points should be thoroughly cleaned, using a fine file only when absolutely necessary. Do not use emery cloth for

cleaning. The points should be set to 0·012 in. Be sure there is no oil on breaker points. Using a medium-bodied oil, put from 30 to 40 drops in the front oiler and 5 to 8 drops in the rear one on each magneto.

Carburettor

Remove and clean the fuel strainer which on the Stromberg NA–R6 carburettor is below the fuel inlet. It is removed by taking off the square-headed nut. The entire carburettor should be inspected to see that all parts are tight and properly made safe. A small quantity of oil should be put on the pump operating mechanism.

Connecting Rods

All rods should be thoroughly cleaned and the oil passages in the master rod should be blown out with compressed air to be sure that there is no obstruction. The master-rod crankpin bearing is a lead-bronze-lined, steel-backed bushing. It should be carefully examined for cracks and scratches in the bronze. The diametric clearance on the crankpin should not exceed 0·0045 in. The bronze bushings for the piston-pin and knuckle-pin bearings should be inspected for scratches. The maximum diametrical clearance on piston pins and knuckle pins should not exceed 0·003 in.

If any rod bearing is in poor condition, the rod should be sent to the makers for bearing replacement. Connecting rods should be checked for nicks or scratches. These marks must be carefully stoned out before assembly. Twisted or bent rods can be checked on a surface plate. Rods should not be bent or twisted to correct these defects. Clearance of knuckle pins in the master rod should never exceed 0·001 in.

Crankshaft

The shaft should be carefully examined for scratches or nicks, which should be stoned out. Nicks in highly stressed parts of the shaft may easily start cracks and cause eventual failure. The oil passages should be flushed out with petrol and blown out with compressed air. All threads should be cleaned up if burred or otherwise damaged. The spline at the rear of the shaft must be free of burrs or the crankshaft-cam drive gear which carries the cam ring will not slip over it easily. Any burrs on the spline at the front of the shaft must be eliminated to facilitate assembly of the airscrew or flywheel.

Crankshaft Bearings

These bearings should spin easily when given a light coating of oil. After washing with petrol and drying the bearings, they may feel slightly rough. If this roughness continues after the bearings have been oiled as above, they should be discarded.

Crankcase

Inspect the case thoroughly for cracks after thoroughly washing with petrol. Clean out tappet-feed lines.

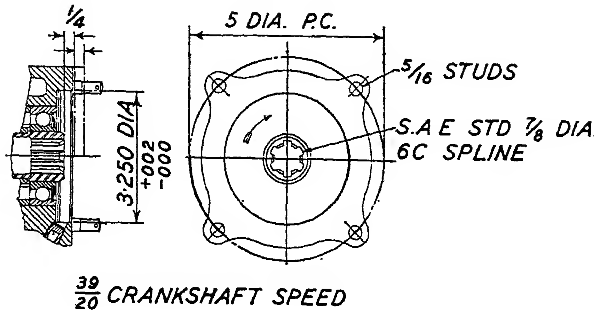

Fig. 14.—Details of generator mounting

Accessory Case

All oil passages should be cleaned out with petrol and blown out with compressed air. The case should then be examined for cracks.

Oil Pumps

After the oil pumps have been dismantled, the parts should be washed with petrol and the bodies inspected for scoring. The square-end drive shaft should be checked to see that there are no burrs.

Oil Relief Valves

Remove both relief-valve housings, and examine the valves and valve seats. Be sure the seats are thoroughly clean and the valves do not bind in the valve chamber.

Oil Filter

Remove the filter and wash carefully in petrol.

Tachometer

Examine carefully to observe indications of scoring in the aluminium housing.

Cam Ring

Inspect the cam lobes for scores or undue wear.

Valve Tappets and Guides

Tappet rollers should be carefully

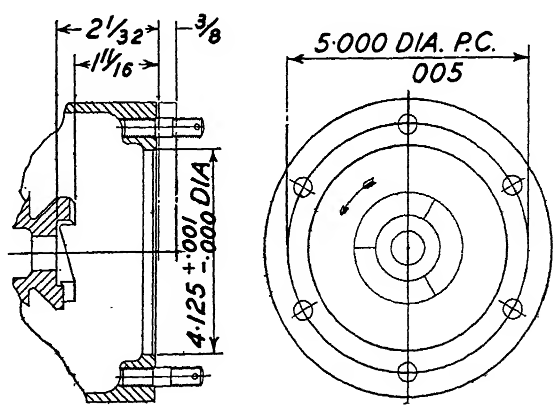

Fig. 15.—Details of starter mounting

checked for roughness at edges. Roller pins showing scuffing or wear should be discarded. The diametric clearance of roller on pin should not exceed 0·005 in. The fit of roller pin in valve tappet should be just tight enough to allow the pin to fall slowly out of the tappet when the latter is held horizontally. The tappets should be examined for scratches or signs of abnormal wear. Examine the tappet guides for cracks or burrs. If in good condition, test each tappet, roller, and pin in its guide.

ASSEMBLY

Connecting Rods

The master rod is mounted on the master-rod bench support and the articulated rods are assembled to it. Knuckle pins should be assembled in the master rod in the same position as before. The Woodruff key locking the pins into position must be held in its slot as the pin is pressed into place. The key must be a snug fit in the master rod, to keep the knuckle pin in position and prevent it from rotating. A new circlip should be used on each knuckle pin when assembling.

Crankshaft

The splined airscrew end of the shaft should be placed in the front crankshaft support, which is mounted in a low work bench. The crankpin should be oiled and the master rod slipped over it. The master-rod bushing is chamfered at the front end to clear the fillet at the front crank cheek. If the rod is reversed in assembly, it will bind on the fillet and the shaft cannot be assembled properly. The crankshaft rear cheek spreader should be used to spread the rear cheek so that it will slip over the crankpin. After drawing the spreader tight, one-quarter turn will allow the cheek to be assembled. Attempts to force the cheek over the pin will cause binding and scoring of both parts of the shaft.

The crankshaft alignment bar must be placed in the slots in the counterweights and the crank cheek tapped until the bar fits perfectly in both slots. Before removing the spreader from the rear cheek, the master rod and clearance must be checked and adjusted to 0·010 in. The spreader can be taken out and the crankshaft clamp bolt threaded into the shaft. This bolt should turn freely into the shaft until tight. If it does not, examine for burrs and clean up the threads.

To determine the correct tension in the bolt, measure the length of the bolt with micrometers before tightening, and then use the crankshaft clamp-bolt wrench to tighten the bolt until it has stretched 0·004 in. when measured with micrometers in the same place as before. The bolt must be turned to line up the slotted end with the cotter-pin hole in the crank cheek. Before locking with cotter pin, the alignment should be checked again with the bar and the master-rod clearance measured.

Crankshaft Bearings

Leaving the crankshaft mounted in a front crankshaft bench support, the crankshaft rear bearing may be pressed on by using the crankshaft bearing puller. The shaft is then mounted in a rear crankshaft bench support, and the puller operated to press on the crankshaft intermediate bearing, first being sure that the spacing ring between intermediate bearing and crank cheek is in place. The crankshaft front bearing is then assembled to the front crankcase by placing this unit on its rear face and tapping the bearing into place with a brass drift. Extreme care should be taken to keep dirt and chips out of the bearing during this operation. The crankshaft-bearing spacer which separates the front and intermediate bearings is slipped over the crankshaft.

The crankcase front portion is then placed over the crankshaft and the crankshaft-bearing puller bolted to it. The spindle is screwed into the threaded end of the shaft, and the driving nut of the tool is operated to press the case down over the front and intermediate bearings. During this operation, care should be exercised to line up the connecting rods in their respective cylinder openings, the master rod being placed in No. 1 cylinder.

If a connecting rod is allowed to swing under one of the crankcase projections, it is sure to become bent as the case is pressed on. When the case is pressed on the shaft, the machined surface of the nose will be flush with the front edge of the front crankshaft bearing. After the oil thrower has been placed on the shaft, the crankcase front cover can be bolted on. The crankshaft front bearing nut should be run up by hand and tightened, using the crankshaft-bearing nut wrench.

Valve Tappets

After inspection, each tappet should be thoroughly oiled and replaced. Use new gaskets when assembling the valve guides.

Crankcase

The rear crankcase is bolted to an assembly stand in a horizontal position. The crankshaft lifting eye is screwed into the front end of the crankshaft and the shaft and front crankcase lifted by a chain hoist attached to the eye. Crankshaft and crankcase are then lowered carefully into the rear crankcase. Care should be taken that the proper cylinders are matched as the case is drawn together. Three or four bolts may be inserted and the crankcase drawn together by pulling up each nut carefully until the two cases meet. The rest of the bolts should then be drawn tight and locked.

Valve Mechanism

The valves are inserted in their respective guides after oiling stems and new circlips are attached. Valve springs, seats, and washers are put

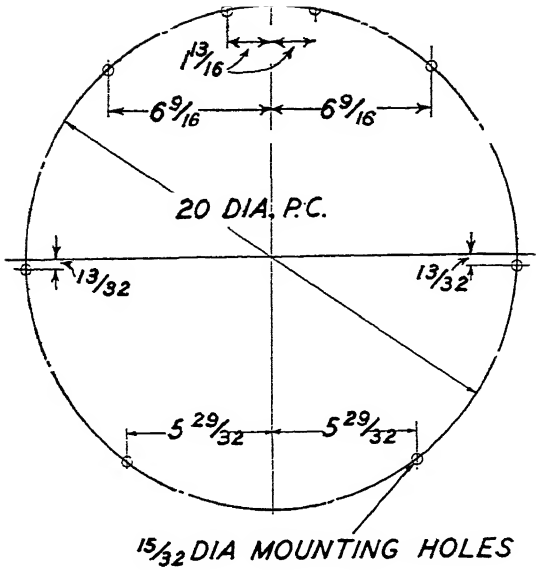

Fig. 16.—Details of mounting ring

in place, depressed far enough so that the valve lock can be slipped into place. The compressor tool is removed and the valve rocker arm is placed in position with the bearing washed and greased before driving the rocker shaft into the rocker box. An aluminium drift should be used for driving the rocker shaft into the rocker box. The rocker-shaft nut must be drawn up solidly.

After tightening the shaft nut, the rocker bearing should be checked for side play and smoothness. If the front end of the rocker arm can be moved sideways an appreciable amount, the shaft nut should be loosened and the rocker arm worked from side to side to dislodge any grit which may have separated the spacing washers between the inner bearing races. If the bearing is still loose after tightening the shaft nut, it must be replaced. If the bearing feels rough, it may be that the rocker-shaft nut has been pulled too tight and the inner races deformed. If a slight slackening of the pressure does not relieve the roughness, the bearing races are probably worn and the rocker bearing should be replaced.

Pistons, Rings, and Pins

After the rings have been assembled to the piston, the assembly may be fitted to its respective connecting rod with the numbered side facing the splined end of the crankshaft. As the pin is tapped into position, the piston must be carefully supported to avoid straining the connecting rod. Be sure that all piston-pin plugs remain in place.

Cylinders and Intake Pipes

In reassembling the engine, the cylinders are attached before the push-rod housings are installed, except in the instance of No. 4 intake and No. 5 exhaust, when the cylinder and push-rod housing are assembled simultaneously. Before any cylinder is assembled to the crankcase, its intake pipe should be attached by means of its flange, but without tightening the nuts securing it to the cylinder head. After placing the gland nut

over the intake pipe, the packing should then be placed about 2 in. from the inner end of the pipe.

No. 1 cylinder should be assembled first. The crankshaft should be turned until the No. 1 piston is brought to the outer end of the stroke. The cylinder should be carefully wiped out with a clean cloth, and both cylinder and piston thoroughly oiled. On all engines a new rubber cylinder-base packing should be used between the cylinder-base flange and the crankcase.

Holding the cylinder firmly against the body to steady it, this unit is placed over the piston. After the rings have been rotated until the gaps are evenly spaced around the piston, they are then compressed until the cylinder is over them. The intake pipe must be guided into its opening until the cylinder flange is on the studs. When properly aligned, the cylinder flange will slide completely down to the crankcase, and in no case should nuts be used to draw the cylinder down.

As soon as the cylinder is in place, and before more than one cylinder-base nut is started, the intake gland nut should be started by hand, but not tightened. The intake gland packing may be pressed into the seat provided for it, by simply pushing it down with the nut. Care should be taken to avoid crossing the threads of the intake gland nut. This nut is started before the cylinder is positively rigid to facilitate this operation.

The cylinder-base nuts may now be placed on and firmly tightened with the special wrench found in the maintenance tool kit. Palnuts are then put on and carefully tightened. If drawn too tightly, the palnut will be stripped and made useless. A special tool may be found in the tool kit, and used to tighten the intake gland nut, which should not be drawn too tightly. Excessive pressure will compress the packing and form a groove in the lower end of the intake pipe. The nuts on the studs attaching the intake pipe flange to the cylinder should be tightened and locked with palnuts.

Push Rods and Housings

On dismantling, the push rods and housings were arranged so that they could be returned to their respective positions. The intake and exhaust push-rod housings have their base flange attached at different angles, and it is very important that no attempt be made to use the wrong type in any position. If such an attempt is made, it is very likely that the housing will be permanently damaged and unfit for further usage.

Place new gaskets over the push-rod housing to crankcase studs. After placing the push-rod housing gland nut over the housing, slide new packing over the tube and pull them down to about 3 in. from the plain end. Making sure that intake and exhaust housings are used in their proper places, insert the small end into the rocker-box opening sufficiently far enough to permit the housing flange to pass over the studs and slip

in place. Place nuts and palnuts on the studs at the flange end, and tighten firmly. By sliding the gland nut towards its position, the packing is pushed in place. Tighten the gland with the special wrench provided in the maintenance tool kit.

The valve-adjusting screws and locknuts are then removed and the push rods inserted through the opening. Replace the screws and locknuts, but do not tighten. It will greatly facilitate the assembling process if, when placing on cylinders Nos. 4 and 5, the push-rod housings next to the oil sump and carburettor are put in place simultaneously with the cylinder.

Accessory Case

If gears have been dismantled, they should be reassembled to the case. Ignition drive shafts, oil-pump drive shaft with gears should be oiled, assembled to the case, and then fixed in place with new circlips. The starter gear is now assembled through the starter opening at the rear of the case and the retainer slipped into place from the front side and attached with screws reached by a screwdriver through the starter opening at the rear and made safe in front. Crankshaft rear-bearing washer is slipped on the rear of the crankshaft with the chamfered side next to the crankcase.

After the cam ring has been cleaned of all dirt and grit, it should be thoroughly oiled and placed over the rear crankshaft with the internal gear facing the rear. The cam-drive gear is then pushed over the rear crankshaft with its sleeve forming a bearing surface for the cam. The scavenge oil-line gasket, a round, flat rubber ring, is then placed over the gasket dowel provided for it in the lower part of the rear crankcase. This gasket should be replaced at every overhaul. It is very important that this gasket remains in its proper position until the accessory case is against it. A common mistake is to omit this gasket altogether or permit it to fall out before the accessory case is in place. The result of this error is that the accessory case floods with oil when the engine is started.

The accessory case may now be mounted. Some difficulty will be experienced in this operation until the mechanic has completed it several times. Due to the fact that there are three sets of interlocking gears, the meshing requires considerable movement of the gear trains before the case will slip in place. However, it makes no difference in what position the gears mesh, as all necessary adjustments can be made with the accessory case intact.

When the gears are all properly meshed, the accessory case will rest with only a slight separation from the rear crankcase. The rear crankshaft nut must then be screwed in several turns, allowing the accessory case to fit snugly to the rear crankcase. Be sure that the rear crankshaft nut is free when tightening the accessory-case nuts. Also be sure that the crankshaft turns freely.

Valve Timing

The special timing pointer should be attached to the two front cover crankcase studs nearest the top centre position and the timing disc slipped on to the crankshaft. Screw a top centre indicator into the front sparking plug hole of No. 1 cylinder. By noting the disc rotation at points of equal piston travel on each side of top centre as shown on the indicator, the piston may be set accurately at top dead centre. If the pointer does not indicate zero on the timing disc, the disc may be rotated to position by unscrewing the clamping screws.

Adjust the valve-tappet clearance to approximately 0·015 in. on all valves regardless of the position of the cam. In this way the possibility of bending the push rod for lack of clearance when turning the crankshaft during the timing operation will be eliminated, and at the same time there will be tension all around the cam. Now tighten the rear crankshaft locking nut, so that the serrations engage in the cam-drive gear serrations and the cam will turn with the crankshaft.

Turn the crankshaft until the intake valve of cylinder No. 7 and the exhaust valve of cylinder No. 2 are open about the same amount. (These valves are the ones nearest cylinder No. 1.) Then on No. 1 cylinder set the clearance between rocker roller and valve stem to 0·124 in., using the feeler gauge and adjusting wrenches found in the maintenance tool kit.

When the clearance has been adjusted, rotate crankshaft in anti-clockwise direction by small movements to the exhaust-valve closing position until the rocker roller is just released. The rear crankshaft nut should then be loosened to disengage the cam, and the crankshaft rotated in an anticlockwise direction to top centre position.

The rear crankshaft nut may then be tightened, taking care that the teeth of the serrations in the crankshaft cam-drive gear engage as the nut is drawn up. It is possible for the teeth to ride on their points without engaging and allowing the timing to change after the engine is in operation. This may be checked by stopping as soon as the nut is snug and working the crankshaft back and forth. If the serrations are not in mesh, the nut may be turned up about one turn farther. After tightening up the rear crankshaft nut, the point of closing of the exhaust valve should be checked up, turning the crankshaft in an anticlockwise direction and determining if the rocker roller is released as the desired position on the timing disc passes the pointer. The serration tooth pitch allows 6° of crankshaft rotation per tooth, so that if the pointer is more than 3° from the zero line at the point of exhaust-valve closing, the crankshaft rear nut should be loosened and the timing corrected. With 0·124 in. clearance, the exhaust valve must close within 3° of top dead centre.

The rear crankshaft nut may now be locked with the tongued lock washer and new circlip, making sure that the circlip covers four points of the nut. The lock washer engages in slots in the rear of the crankshaft starter gear. The tachometer assembly is then bolted in place, the squared

end of its drive shaft engaging with a similarly shaped opening in the rear crankshaft nut. Valve adjusting screws and locknuts are screwed into place, and the clearance of all valves set at 0·010 in.

Magneto Timing

Rotate the crankshaft until the pointer indicates the desired position of magneto firing for the right-hand magneto as given on page 116, *before top centre* on the *compression* stroke of No. 1 cylinder. After the magneto points have been checked for proper alignment and the points set for 0·012 in. gap, the right-hand magneto (looking towards the accessory case from the rear) is ready to be attached. First, however, remove the inspection plate at the rear of the magneto. By turning the distributor gear, bring into alignment the marks on the distributor gear and the front plate of the magneto. This puts the magneto in firing position for No. 1 cylinder. The magneto coupling is then inserted into the serrated magneto drive gear without turning the rotor. The mounting studs may now be tightened enough to hold the magneto in position against the accessory case. This process is exactly repeated, except with the engine crankshaft in position as indicated on page 116, for the mounting of the left-hand magneto.

The magnetos are now approximately in the firing position. Before checking the breaker opening position, each magneto should be rotated in a counterclockwise direction (looking towards the accessory case from the rear) by tapping the mounting flange until it is near the end of the travel permitted by the slots. The crankshaft may then be turned backwards a little and brought slowly up to the firing position to take the back lash out of the driving-gear train. If the magnetos have manual-control spark advance, be sure that the control levers are in the full advance position.

If available, a 0·0015-in. feeler should be inserted between the breaker points, and each magneto flange tapped in a clockwise direction until the exact point of release is reached (see page 116). Cellophane is a very good substitute if a 0·0015-in. feeler is not available. After tightening the mounting nuts, the timing should be checked by backing up the crankshaft and turning it slowly forward in short intervals, and determining if the feeler is released the instant the disc reaches the sparking advance position. All traces of the cellophane must be removed before replacing breaker cover.

If a light is used to indicate the opening of magneto breaker points, the contact springs brushing the bronze arm carrying the breaker points must be insulated by inserting a piece of stiff paper between springs and arm. The breaker points may now be connected in series with battery and light.

A common mistake of inexperienced mechanics is to neglect to turn the crankshaft a revolution after timing the valves, thereby setting the magnetos so that they fire on the wrong stroke.

Check Valve Clearances

The cold clearance for both intake and exhaust valves is 0·010 in. The crankshaft should be turned until No. 1 cylinder is on top centre of its firing stroke to begin the adjustments. In the maintenance tool kit, wrenches will be found for the adjustments. The clearances should be checked in rotation in accordance with the firing order of the engine, that is: cylinders 1–3–5–7–2–4–6, each time having the piston on top centre of the firing stroke of the cylinder being checked. A wide spline or set-screw indicates the top centre position, but the firing stroke must be determined from the valve operation. After all clearances have been checked, replace the rocker covers, using new gaskets throughout. Be sure that all covers are in their proper positions. Tighten all rocker-cover nuts firmly, and lock in place by new palnuts.

Replace the oil sump with new gaskets.

Sparking Plugs

All plugs should be thoroughly cleaned and replaced if broken or burned. The point clearance should be 0·015 in. Plugs should then be screwed into place and ignition cables attached to them. Mica sparking plugs must not be left standing in petrol.

Carburettor

Bolt the carburettor to the rear crankcase, using a new gasket.

It is advisable to inspect the fuel and oil lines for leaks and to check control linkage for undue wear and excessive travel. The mounting bolts should also be tightened.

RUN IN

It is very important that an engine be carefully run in after a complete or top overhaul. The length of time necessary for this depends upon the new parts installed during the overhaul and the facilities available for the running-in process. A flying airscrew does not cool the engine properly if the aeroplane is not in flight, and any continued full-throttle operation should be avoided on the run in unless a special cooling airscrew is used. It is also advisable to have a thermocouple attached at the base of the sparking plugs and not to allow the cylinder-head temperature to exceed 500° F.

A pressure gauge should be attached to both the high- and low-pressure oiling systems. The high-pressure connection is made at the same place as in the aeroplane installation, while the low pressure (overhead oiling) may be measured by removing the $\frac{1}{8}$-in. pipe plug located approximately 1 in. and directly above the high-pressure oil connection, and attaching a pressure gauge.

When new pistons or bearings are installed, at least 5 hours of run-in

time should be put on the engine. New rings may be broken in sufficiently for flight in, possibly, 3 to 4 hours.

The engine should be run at approximately 700 r.p.m. until the oil is thoroughly warm. Then at intervals of 30 minutes the speed should be increased by 100 r.p.m. If a special airscrew is not being used, a speed of approximately 1,500 r.p.m. should not be exceeded for more than a few minutes at a time with the aeroplane on the ground. If a thermocouple is used, speeds may be increased until the cylinder-head temperature reaches 500° F. The remainder of the run-in may be put on in cruising flight, with a final run of about 30 minutes at full throttle in flight. Any flight run in should be made over the airport in order that a quick landing may be made if any trouble develops.

If new pistons have been installed, the cylinders should again be removed and the pistons and cylinder walls inspected. If found to be in perfect order, reassemble, and warm up for 20 minutes before final test flight. The operation for the next 10 hours should be the same as with a new engine.

TIMING DATA

Valves

With exhaust and intake valve clearance set at 0·124 in., cylinder No. 1 valves begin to open and completely close as follows :

Exhaust valve opens	49° B.B.C.
Exhaust valve closes	0° T.D.C.
Intake valve opens	4° A.T.C.
Intake valve closes	0° B.D.C.

The above should not be confused with the operating timing of the engine, since same applies only when the valve-tappet clearance is 0·124 in. Before the engine is operated, all valve-tappet clearances should be reset to 0·010 in. cold. Timings within 3° of the above-given figures are permissible.

Magnetos

Manual spark advance control :

Right-hand magneto (front plugs) fires 32° B.T.C.

Left-hand magneto (rear plugs) fires 29° B.T.C.

Note.—Above represents the timing with advance control lever in " full-advance " position.

Automatic spark advance control :

Right-hand magneto (front plugs) fires 18° B.T.C.

Left-hand magneto (rear plugs) fires 15° B.T.C.

The magneto will fire *just* as the points break.

CONTINENTAL A-50, A-65, and A-75 ENGINES

THE Continental engines described in the following pages are four-cylinder, horizontally opposed, four-cycle, air-cooled engines with overhead valves. We are indebted to Messrs. Continental Motors Corporation for the technical details given below.

ENGINE DESCRIPTION

Crankcase

The crankcase is a two-piece heat-treated aluminium-alloy casting bolted together at the vertical lengthwise plane through the crank and camshafts. There are rigid transverse webs to hold the three main bearings and the three camshaft journals. A specially designed oil seal prevents oil leakage at the airscrew. Large tappet guides are formed in the crankcase in a plane below and parallel to the cylinders. Cast-in lengthwise tubes lead oil pressure to the tappet guides, camshaft, and main bearings. Circumferential stiffening ribs under the cylinder pads give additional strength and stiffness to the cylinder hold-down bosses. Four engine-mount bosses for $\frac{3}{8}$-in. bolts are provided at the rear of the crankcase as in radial engines. To the rear and on the bottom of the crankcase there is a large flange for supporting the integral oil sump.

Cylinders

Heat-treated, aluminium-alloy cylinder heads are screwed and shrunk to forged-steel barrels. Closely spaced cooling fins are provided on barrels and cylinder heads to give ample and efficient radiation surface. Cylinder bores are ground to mirror finish and held within extremely close limits. The A-50 and A-65 engines have aluminium-bronze sparking-plug inserts and valve seats shrunk into the cylinder heads, while the " A-75 " has austenitic-steel exhaust-valve seats and aluminium-bronze sparking-plug inserts. Rocker boxes are case-integral with the heads and provided with oil-sealed covers. Drains are provided on each cylinder for the scavenging of the rocker boxes.

Pistons

All models have heat-treated aluminium-alloy " Lo-Ex " permanent mould pistons. The A-75 pistons are internally ribbed for greater strength and heat dissipation. Two compression rings and two oil-

THE CONTINENTAL A-50
Series 4 and 5

Model:	Continental A-50, Series 4 and 5 A.T.C.
Type:	Four-cylinder, horizontally-opposed, four-cycle, overhead-valve, air-cooled.
Rating:	50 h.p. at 1,900 r.p.m.
Cruising r.p.m.:	1,700 to 1,850 r.p.m.
Bore and stroke:	$3\frac{7}{8} \times 3\frac{5}{8}$ in.
Displacement:	171 cu. in.
Compression ratio:	5·4 : 1.
Firing order:	1-3-2-4.
Direction of rotation:	Counter-clockwise (facing airscrew end).
Oil pressure:	30 to 35 lbs./sq. in.
Capacity of oil sump:	4 U.S. quarts.
Oil temperature (max.) (Mfgrs.):	215° F.
Oil consumption (cruising):	$\frac{1}{4}$ pint per hour.
Approved fuel:	65 octane.
Recommended fuel:	72 octane or better.
Fuel consumption (cruising):	$3\frac{1}{2}$ U.S. gals. per hour.
Ignition:	Bendix-Scintilla, single or dual.
Carburation:	Stromberg NA-S3.
Sparking plugs:	Champion M-3-1.

scraper rings, one of the latter being below the piston pin, are provided on the A-50 and A-65 piston, while the A-75 piston has a third compression ring above the piston pin, thus making five rings on the A-75 piston. The A-50 pistons have a compression ratio of 5·4 : 1, while the A-65 and A-75 pistons have a compression ratio of 6·3 : 1.

Connecting Rods

Connecting rods are of conventional design and of heat-treated alloyed-steel forgings. The split big-end bearing is the replaceable thin steel-back shell-type with copper-lead lining. At the piston-pin end is a pressed-in bronze bushing. The connecting rods used in the A-75 have specially drilled oil holes for extra oiling of all cylinder bores.

Crankshaft

The alloy-steel, one-piece, four-throw crankshaft is supported by three steel-backed copper-lead-lined main bearings. The crankshaft is drilled for lightness and to provide pressure for lubrication of crankpin journals. The crankshaft-end clearance is fixed by the front main bearing setting between the forward crank cheek and a collar machined on the shaft. This construction provides a thrust bearing for tractor or pusher installation.

Camshaft

The cast-steel camshaft has hardened cams and journals. There are six cam lobes, three journals, and an overhung eccentric at the forward

THE CONTINENTAL A-65

Series 1 and 3

Model:	Continental A-65, Series 1 and 3 A.T.C.
Type:	Four-cylinder, horizontally-opposed, four-cycle, overhead-valve, air-cooled.
Rating (Series 1):	65 h.p. at 2,350 r.p.m.
Rating (Series 3):	65 h.p. at 2,300 r.p.m.
Bore and stroke:	$3\frac{7}{8} \times 3\frac{5}{8}$ in.
Cruising r.p.m.:	2,000 to 2,150 r.p.m.
Displacement:	171 cu. in.
Compression ratio:	6·3 : 1.
Firing order:	1-3-2-4.
Direction of rotation:	Counter-clockwise (facing airscrew end).
Oil pressure:	30 to 35 lbs./sq. in.
Capacity of oil sump:	4 U.S. quarts.
Oil temperature (max.) (Mfgrs.):	215° F.
Oil consumption (cruising):	$\frac{1}{4}$ pint per hour.
Recommended fuel:	72 octane or better.
Fuel consumption (cruising):	$4\frac{1}{4}$ U.S. gals. per hour.
Ignition:	Bendix-Scintilla magnetos, single or dual.
Carburation:	Stromberg NA-S3A1.
Sparking plugs:	Champion M-3-1.

end for operating a fuel pump. The exhaust cams are adjacent to the journals. The intake cams are common to opposing cylinders. At the rear end is a flange for attachment of a gear by cap screws.

Valve Gear

Hydraulic tappets fit aluminium-alloy guides machined in the crankcase so sealed as positively to prevent oil leakage. Tappets are drilled in such a manner that an oil passage is provided from the tappets to the push rods, rocker-arm bearings and rocker end. Push rods are made of light-steel tubing with pressed-in ball ends, hardened and ground, and drilled their entire length to provide an oil passage to the overhead mechanism. The push rod is fully enclosed, and the outer end fits into a socket in the rear of the valve rocker. The rocker acts directly on the valve through a specially designed "foot" so constructed as to prevent side-thrust on the valve stem. Splash keeps valve-guides oiled at all times. Oil is returned to the crankcase by the push-rod housing.

Accessory Case

The accessory gearcase casting at the anti-airscrew end of the engine provides support for ignition units, oil pump, and tachometer drive. (Provisions for starter on special models.) The gearcase has the oil suction tube, the oil drain, oil screen, the pressure relief valve, and oil lines to match the several crankcase oil lines. The entire assembly with accessories is removable as a unit.

THE CONTINENTAL A-75

Series 3

Model :	Continental A-75, Series 3 A.T.C.
Type :	Four-cylinder, horizontally-opposed, four-cycle, overhead-valve, air-cooled
Rating :	75 h.p. at 2,650 r.p.m.
Cruising r.p.m. :	2,350 to 2,450 r.p.m.
Bore and stroke :	$3\frac{7}{8} \times 3\frac{5}{8}$ in.
Displacement :	171 cu. in.
Compression ratio :	6·3 : 1.
Firing order :	1-3-2-4.
Direction of rotation :	Counter-clockwise (facing airscrew end).
Oil pressure :	30 to 35 lb./sq. in.
Capacity of oil sump :	4 U.S. quarts.
Oil temperature (max.) (Mfgrs.) :	215° F.
Oil consumption (cruising) :	$\frac{1}{4}$ pint per hour.
Recommended fuel :	72 octane or better.
Fuel consumption (cruising) :	$4\frac{1}{2}$ U.S. gals. per hour.
Ignition :	Bendix-Scintilla magnetos, single or dual.
Carburation :	Stromberg NA-S3A1.
Sparking plugs :	Champion M-3-1.

Intake and Exhaust System

Carburation is supplied by an up-draft Stromberg NA-S3 (A-50) NA-S3A1 (A-65 and A-75) carburettor connected to an " X " manifold. This manifold is attached by two studs to the underside of the crankcase midway between cylinders. Steel intake pipes connect this manifold to each of the four intake ports. A primer connection is provided at each of the cylinders to facilitate cold-weather starting. There is also a primer connection just above the carburettor and below the manifold " X."

Lubrication

The A-50, A-65, and A-75 engines are essentially dry sump engines. but to minimise installation problems and to reduce the number of external oil lines, an integral sump has been attached directly to the crankcase. Oil is drawn from the oil tank through a suction tube extending down into the tank and delivered under pressure to a filter from which it goes through drilled passages in the accessory and main cases to all drive bearings, through the crankshaft and to the crankpins. On the A-75 models, oil is ejected from each connecting-rod cap to the adjacent cylinder bore, thus ensuring adequate lubrication under the most severe conditions.

Engine oil from the pressure pump is carried through drilled passages in the crankcase to the hydraulic tappets. After entering the tappets, it travels out through the overhead mechanism through hollow push rods, and is spilled over the rocker arm and valve mechanism. As it drains away, it thoroughly oils the valve stems and valve guides. The oil is

returned to the crankcase by way of the push-rod housings, and drains back into the integral oil sump through the large opening provided for this purpose. In the A-50, A-65, and A-75 models, cylinder walls and piston pins are lubricated by a spray, whilst the system discussed in the preceding paragraph is provided for supplementary lubrication in the A-75. Excess oil in the crankcase is returned by gravity to the oil sump. The pressure relief valve is set to give approximately 33 lb. of pressure at speeds of from 1,900 to 2,650 r.p.m.

Testing

Every engine is run 3½ to 5 hours, of which 1 hour is at full throttle with airscrew load. It is then completely disassembled and inspected. After reassembling, it is given an additional half-hour check run at full load, full throttle. The thoroughness employed in testing production engines is a safeguard to Continental quality. Performance of engines in the field amply justifies the care expended in proving the engine's right to bear the Continental winged seal of quality.

MAINTENANCE

Due to the modern improvements and engineering features of the Continental A-50, A-65, and A-75, required maintenance has been reduced to a minimum. As a general rule, these engines will need only the engine check every 100 hours, and a major overhaul every 500 to 600 hours. The operating time before a major overhaul is, of course greatly dependent upon the care the engine has been given and the type of service to which it has been subjected. Experience has shown that operating periods of from 500 to 600 hours between major overhauls can easily be reached by normal operation and maintenance.

No general top overhaul is recommended, but in the event of a valve beginning to leak or the engine performance falling off, the cylinder causing the trouble should be located and removed and the condition corrected. However, if the engine behaviour indicates that special maintenance is needed before a major overhaul, it is well to make a careful check of all controls, sparking plugs, mixture and spark setting, ignition breaker points, fuel system, and airscrew to make sure that poor functioning of one of these items is not affecting the performance.

ENGINE CHECK (Every 100 Hours)

An engine check is done without removing the engine from the aeroplane and is as follows :

(1) Check all engine-mounting bolts to see that they are tight. If the engine has a rubber mounting, the bolts at the engine-mounting lugs should be tightened firmly, but should not be drawn down too solidly.

(2) Check airscrew hub bolts for tightness, and check airscrew for

track, making corrections if necessary. The airscrew should track within $\frac{1}{8}$ in.

(3) Inspect for oil leaks. Any undue amount of oil appearing at any point on the engine is an indication of trouble, and should be thoroughly investigated.

(4) Inspect fuel and oil lines for breaks or loose connections.

(5) Check control linkages for undue wear, missing cotter pins, and see that full travel of all controls is obtained.

(6) Check altitude control adjustment, making sure that positive and full movement of the control arm on the carburettor is obtained.

(7) Remove and clean the scavenge oil strainer located in the accessory case below and back of No. 2 cylinder. Clean fuel sediment bulb.

(8) Check the sparking plugs, clean and reset points to 0·015 in.

(9) Check ignition wires for breaks or broken insulation, and clean terminals going into the magneto.

(10) Inspect ignition breaker points and reset according to manufacturer's specifications.

(11) Check engine thoroughly for loose bolts and nuts, and make sure that all palnuts are in place.

(12) Wash the engine thoroughly with a cleaning fluid, preferably not inflammable to avoid fire hazard.

MAJOR OVERHAUL (Every 500–600 Hours)

For a major overhaul, the engine must be removed from the aeroplane. A clean table should be provided on which the engine parts may be arranged for inspection as they are removed and cleaned. Keeping parts grouped according to cylinders and assemblies will greatly facilitate inspection and subsequent assembly operations.

Do not stamp numbers on parts for identification on assembly, as failure of such parts may be caused by cracks originating at the marks made by the numbering die. Small paper tags may be used for identifying and locating parts not numbered at the factory.

Tools

A minimum number of special tools is required for the major overhauling of the A-50, A-65, and A-75 engines. Aside from a valve-spring compressor, no other special hand tools are required. Bench tools, such as an automatic valve refacing machine, valve-seat refacing tool set, and similar standard service tools can be obtained from various manufacturers who specialise in aeroplane service tools.

Disassembly

The following is the procedure which should be used in disassembling and assembling the A-50, A-65, and A-75 engines, assuming same have been removed from the aeroplane:

(1) The sparking plugs should be removed and stored in a safe place free from dirt. Remove the ignition wire conduits and magneto (or magnetos). The exhaust manifolds are also removed. Remove the carburettor by unscrewing the four $\frac{1}{4}$-in. nuts that hold the carburettor to the intake manifold.

(2) Remove the oil sump by removing the six $\frac{7}{16}$-in. castle nuts that hold it to the crankcase, and drop it straight down. The oil intake pipe can be removed by unscrewing the hex portion at the top by using a $\frac{7}{8}$-in. wrench.

(3) Loosen the hose connections at the cylinder on all the intake pipes, and slide the rubber hose towards the carburettor. Now remove the two $\frac{5}{16}$-in. nuts holding the intake manifold to the crankcase, thus allowing the intake manifold cluster to be dropped down and removed.

(4) Next, remove the nuts and palnuts holding the rocker-box covers to the cylinders, and remove. After the rocker covers are removed, the rocker-arm shaft may be pushed out with the finger, provided the cam is in such a position that the intake and exhaust valves are closed. As the rocker shafts are pushed out, the rocker arms may be removed, and the push rod may be pulled out of the push-rod housings.

(5) Loosen the clamps holding the hose connections at the foot of the push-rod housing, and push the clamp and rubber hose back up on the housing towards the cylinder head. This entirely disconnects the housing from the flanged foot and crankcase. After the six cylinder-base nuts have been removed, the cylinder and push-rod housing may be taken off as a unit. Care should be taken to see that the piston does not drop down and become damaged as the cylinder is removed from it. During this operation the piston should be on the outer end of the stroke. As soon as the cylinder is removed the piston pin should be pushed out and the piston removed, so that no damage will occur to it. Remove all four cylinders by this same procedure.

(6) Remove each push-rod housing flanged foot by removing the nuts holding it to the crankcase. Remove the small caps on the push-rod end of the hydraulic valve tappets, and then with a small wire hook the inside mechanism of the tappet may be pulled out. Usually the piston and cylinder of the hydraulic tappet will stick together, but if they do not, they may be taken out separately by the use of a pair of thin-nosed pliers. Be sure to keep the tappets numbered according to the order in which they are removed, and see that the assemblies are kept grouped together. The tappet housing (or cam follower) cannot be removed until the crankcase is disassembled.

(7) Now the thirteen $\frac{5}{16}$-in. nuts holding the accessory case to the crankcase proper may be removed. The accessory case may then be lifted off as a complete unit. The oil pump, relief valve, and tachometer drive units remain intact in the accessory case.

(8) After the accessory case is removed, remove the four $\frac{1}{4}$-in. cap

screws holding the cam gear to the cam. It will be noted that these four cap screws are so spaced that the gear cannot be replaced incorrectly. Also note that the cam and crankshaft gears are marked for the correct timing of the valves, and in rebuilding the engine these markings must mesh. It will not be necessary to remove any of the other gears at this time, but the cam gear must be removed before the crankcase can be disassembled.

(9) Remove all of the $\frac{1}{4}$-in. nuts holding the two halves of the crankcase together. These nuts are on the centre line of the crankcase on both top and bottom of the engine. Now remove the two $\frac{7}{16}$-in. nuts which are attached to long studs located at the front of the crankcase on the Nos. 2–4 side (referring to cylinder numbers), and also the two $\frac{7}{16}$-in. nuts to be found one just above the intake pipes between the cylinders and one between and to the rear of No. 1 cylinder on Nos. 1–3 side.

(10) Now with the motor lying on its Nos. 1–3 side, the Nos. 2–4 side of the case may be lifted off. Lift the crankshaft, together with the connecting rod, out of the crankcase.

(11) It will be noted that the main bearings are of the shell type, and are machined to fit exactly, and require no reaming whatsoever. Further, no adjustment of clearances is required. All bearings have "lips" on them, and can be replaced only in their proper positions.

(12) Remove all connecting rods from the crankshaft.

(13) Remove the four $\frac{1}{4}$-in. nuts holding the oil-pump gear plate to the accessory case, and the oil-pump gears may then be removed. The aluminium casting housing the tachometer drive in the accessory case has a *left-hand thread*, and the same can be unscrewed and removed from the case.

(14) By compressing the valve springs in the rocker box, the locks may be removed from the valve stem, and the spring seat, springs, and washers may be removed. In removing the valves from the guides, care should be exercised to see that they do not scratch or mar the cylinder walls.

INSPECTING THE ENGINE

Crankshaft

Clean the crankshaft oil-pressure holes thoroughly with clean petrol, and blow out with air. Inspect journals for scuffing and check journal fillets for cracks.

Bearings

Inspect the main and connecting-rod bearings for cracks or flaws. If cracks or flaws are visible, replace both halves of the bearing. If it is necessary to replace any main or connecting-rod bushings, the same may be done by simply pressing in new bushings with the fingers. Connecting-rod upper and lower bushings are identical except in the A-75,

where the cap end bushing is drilled for an oil passage. Check bronze piston-pin bushings for signs of scuffing or overheating, and if bushing appears burned or rough, make replacement.

Pistons, Piston Pins, and Piston Rings

Remove all rings, clean carbon from ring grooves and heads of pistons. Do not polish the contact surfaces of the piston. If slight score marks are visible, stone lightly with a fine Pike stone. Stone only enough to remove the metal which has piled up, as deep scratches cannot be removed. If scoring is heavy, the pistons must be replaced. Inspect the pin bosses. If worn, the piston must be replaced. Check piston-ring grooves for wear. If worn beyond service tolerances, the piston must be replaced. Piston rings should always be replaced at the time of a major overhaul.

Cylinders

Check for scores. Very light scores can be removed with crocus cloth. If the cylinders have heavy scores, they should be replaced. Check valve-seat inserts, and if badly burned, replace. (Valve-seat replacements can only be made with special equipment, and if it is necessary to do this work, same should be returned to the factory or to a shop well equipped for this type of work. Cylinder barrels can also be replaced by the factory.) Check valve guides, and if worn beyond the tolerances given by the manufacturers, they should be replaced. Check cylinder heads thoroughly for cracks and deep scratches. Any dents or deep scratches should be stoned out, since same may result in a failure.

Valves and Valve Springs

Recut all valve seats ; reface all valves, replacing those that are not cleaned up on valve refacing machines. Regrind all valves. Clean all gum from the valve stems, but do not polish, as this will remove the hard glaze which is desirable. Check all valve springs for wear, tension, and breakage.

Camshafts

Inspect lobes on the cam. If scuffed, stone lightly. Inspect cam bearings for scratches. If the cam lobes are scuffed, the cam followers are probably also scuffed and will have to be stoned lightly on the inner end.

Crankcases

Check crankcase thoroughly for fatigue cracks. Clean with petrol, blowing out all oil lines.

Pressure Relief Valve

Clean thoroughly and reinstall. The plunger should work freely in its cage without sticking.

Oil Pump

Check the oil-pump gears, and if nicked or scratched, stone lightly. Remove all burrs. If the gears are badly dented or worn, they should be replaced.

Tachometer Drive and Crankshaft Oil Seal

It is desirable always to replace all gaskets and packings at the time of a major overhaul.

Hydraulic Tappets

Inspect the tappet mechanism thoroughly for burrs and gum formation. The tappet is a very rugged mechanism, and no damage is likely to occur to it if handled with any reasonable amount of care. Care should be exercised to see that it is not dropped or nicked because of coming in contact with other metallic objects. The tappet is composed of only four parts which can be disassembled. These parts are described as the cap, cylinder, piston, and guide. The tappets should be washed thoroughly and the piston should work freely in the cylinder. If either the piston or cylinder is damaged, then both parts must be replaced. The guide, or actually the cam follower, and the cup are supplied as units separate from the piston and cylinder; however, all may be obtained as a complete hydraulic tappet assembly. A wire may be inserted in the tube at the end of the cylinder to relieve the ball check so that the piston can be moved freely, thereby allowing a better examination of the unit.

Magneto

Inspect the points and true up if pits are visible, making sure that the points are flat against each other. Oil only according to magneto instruction book. Inspect wiring harness. If wires are damaged, they should be replaced. See that all wires are well anchored and that positive contact is made. Of special interest is the fact that the magnetos of the type used on these engines do not have any set point-gap clearance. When the magneto is timed internally correctly, the point gap is automatically set.

Carburettor

The carburettor needs practically no attention apart from draining the float bowl of water, which can be done by removing the $\frac{1}{4}$-in. pipe plug in the bottom of the float chamber.

Gaskets and Packings

It is always the best policy to use new gaskets and packings throughout whenever reassembling an engine.

MAGNETO TIMING

The A-50 and A-65 engines are supplied in dual- and single-ignition models, while the A-75 is supplied only in the dual-ignition model. In all instances, the right magneto, facing the accessory case from the rear of the engine, fires the top plugs, while the left magneto fires the lower plugs.

For the Single Magneto A-50-4 Engine

Set the engine at 28° Before Top Dead Centre on the firing stroke. This puts the engine in firing position for No. 1 cylinder. The magneto coupling is then inserted into the serrated magneto drive gear without turning the motor or magneto. The mounting studs may be tightened enough to hold the magneto in position against the accessory case.

The magneto is now approximately in firing position. Before checking the exact breaker opening position, the magneto should be rotated in a counter-clockwise direction by tapping the mounting flange until it is near the end of the travel permitted by the slots. The crankshaft may then be turned backward a little, and brought slowly up to firing position to take the backlash out of the driving-gear train.

If available, a 0·0015-in. feeler should be inserted between the breaker points, and each magneto flange tapped in a clockwise direction until the exact point of release is reached. Cellophane is a very good substitute if a 0·0015-in. feeler is not available. After tightening the mounting nuts, the timing should be checked by backing up the crankshaft and turning it slowly forward at short intervals to determine if the feeler is released the instant the disc reaches the 28° mark. All traces of Cellophane must be removed before replacing the breaker cover.

For the Dual Ignition A-50-5 Engine

The procedure as described above is repeated for each magneto, except that for the left magneto (firing lower plugs), the crankshaft location for attaching the magnetos should be 28° Before Top Dead Centre, and 25° Before Top Dead Centre for the right magneto (firing upper plugs). The magnetos on the dual ignition model rotate in opposite direction to that of the single ignition model, and this should be borne in mind in following the above instructions.

For the Single Ignition A-65-1 Engine

The same procedure as described above for the A-50-4 engine is followed, except that the magneto timing should be 30° Before Top Dead Centre.

For the Dual Ignition A-65-3 Engine

The procedure described above for the A-50-5 engine is followed exactly, with the exception that the timings of both magnetos should be 30° Before Top Dead Centre.

For the Dual Ignition A-75-3 Engine

The procedure as described above for the A-50-5 engine should be followed exactly with the exception that the left magneto (firing lower plugs) should be set at 32° Before Top Dead Centre, while the right magneto (firing top plugs) should be set at 30° Before Top Dead Centre.

Tighten and safety magneto-flange nuts. Install all valve-rocker covers and safety. Check over the entire engine and be sure that palnuts are used on all exposed nuts.

The engine is now ready to be reinstalled in the aeroplane.

ENGINES

INDEX